Anthropometric predictors of dyslipidemia among adults in Saudi Arabia

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ABSTRACT

BACKGROUND: dyslipidemia and obesity are key independent modifiable risk factors for many non communicable chronic diseases. Patterns of association between these factors may help prevention and control. This study aims to assess the association between lipids profile and obesity among adults in Kingdom of Saudi Arabia and identify anthropometric predictors of dyslipidemia.

METHODS: data were collected and analyzed from a cross-sectional study using WHO STEPwise approach that included 4 990 Saudi adults aged 15- 64 years selected by stratified, multistage, cluster random sampling technique. Lipid profiles (cholesterol categories and triglycerides) were determined spectrophotometrically by colorimetric biochemical methods. Obesity was determined by calculation of body mass index (BMI=Kg/m^2), waist and hip circumferences and ratio and waist to height ratio.

RESULTS: the overall prevalence of obesity ranged from 33.8 to 44.4 % and the overall dyslipidemia prevalence ranged from about 25 to 44% depending on type of dyslipidemia and anthropometrics used. Prevalence of dyslipidemia and mean concentration of lipids profile were generally significantly higher in obese than non obese. The indicator waist/height ratio was the significant predictor for all types of dyslipidemia and all levels of serum lipids.

CONCLUSIONS: the prevalence dyslipidemia and obesity are high and they are positively associated. Waist/height ratio was the most important predictor of dyslipidemia among adults.

Key words: Dyslipidemia; Obesity; Adults; Anthropometrics; Saudi Arabia

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INTRODUCTION

Obesity is a complex, multi-factorial, chronic condition that is associated with mortality and significant morbidity and is prevalent worldwide [1-3]. Studies in the Kingdom of Saudi Arabia (KSA) and other Gulf countries have highlighted the increasing burden of the reported 13–50%

prevalence of overweight and obesity in adults [4-9]. This pattern is comparable to other countries that have witnessed significant economic growth, resulting in a rise in obesity and obesity-related diseases [10]. Dyslipidemias are disorders of lipoprotein metabolism, including lipoprotein overproduction and deficiency. They may manifest as elevated total cholesterol (TC), high low-density lipoprotein cholesterol (LDL), and low high-density lipoprotein cholesterol (HDL) levels. Most triglyceride (TG) levels are considered atherogenic [11]. There is a general increasing trend in dyslipidemia with increasing obesity, in both males and females, in many communities [12-19]. In response to the increasing burden of obesity in KSA, an Obesity Chair was established to sponsor research and interventions designed to prevent and treat overweight and obesity [20]. The World Health Organization (WHO) Regional Office for the Eastern Mediterranean (EMRO) reviewed and discussed national and regional plans for the establishment of guidelines on dyslipidemia, obesity, and diabetes primary prevention and care [21]. Both obesity and dyslipidemia appear to develop from an interaction of genotype and the environment. This interaction involves the integration of social, behavioral, cultural, physiological, metabolic, and genetic factors. Using simple, noninvasive, anthropometric methods, diagnosing obesity as a possible predictor of dyslipidemia is expected to be helpful in efforts to prevent, diagnose early, and control both morbidities. This study aims to study anthropometric predictors of dyslipidemia.

METHODS

This is a cross-sectional, community-based study covering the whole population of KSA in 2005. The WHO STEPwise approach to Surveillance (STEPS) of Non-Communicable Diseases (NCD) risk factors was the basis for conducting the survey and for collecting the data [22, 23].

The STEPS approach focuses on obtaining core data on the established risk factors that determine the major disease burden. It is sufficiently flexible to allow each country to expand on the core variables and risk factors, and to incorporate optional modules related to local or regional interests. The STEPS instrument covers three different levels of "steps" of risk factor assessment. These steps are:

- Questionnaire
- Physical measurements
- Biochemical measurements

Study population

All Saudi population aged 15–64 years from all the 20 health regions of the country comprised the study population.

Sampling

A multistage stratified cluster random sampling technique was used to recruit the study subjects. Stratification was based on age (five 10-year age groups) and gender (male/female, two groups). All health regions of the country (20 regions) were covered. Based upon the proposed methodology of the WHO STEPwise approach, a sample size of 196 was calculated for each of these ten strata. A list of all Primary Health Care Centers (PHCCs) in each region was prepared; 10% of these PHCCs were randomly chosen and allocated a regional sample proportionate to the size of their catchment population in sampled PHCCs. To identify the households, a map of the health center coverage area was used to choose the houses. Each house was assigned a number, and a simple random draw was made.

Data collection

Data were collected using the WHO STEPwise approach [22, 23], which included a questionnaire, physical and anthropometric measurements, biochemical measurements including serum lipids, chronic diseases, and risk factors. The questionnaire was translated into Arabic by a team of physicians and then back-translated to ensure the accuracy of the translation. The Arabic instrument was pre-tested and corrected before using it on 51 eligible respondents for wording and understanding of the questions. Necessary adjustments were made to the instrument in light of the pre-test.

Data collectors

Data were collected by 54 male and 54 female collectors who worked in teams. Each field team was made up of four persons: a male

data collector, a female data collector, a driver, and a female assistant. Data collection teams were supervised by a hierarchy of a local supervisor, regional coordinators, and a national coordinator.

Training of data collectors

All individuals involved in data collection attended a comprehensive training workshop that included interview techniques, data collection tools, practical applications, and field guidelines.

Analytical techniques

Blood (5 ml) was collected in the morning, after the participants had abstained from eating overnight. Sodium heparin was used as an anticoagulant, and the samples were centrifuged at 3 000 × g for 15 min at 20°C to separate plasma. Aliquots were prepared for storage (−20°C or −80°C) until further analysis. Total cholesterol (TC), triglycerides, and glucose were measured with commercially available enzymatic colorimetric kits from QCA (Amposta, Spain). Seriscann Normal (ref 994148) (QCA, Amposta, Spain) was used for quality control measures. Serum high-density lipoprotein cholesterol (HDL-C) levels were analyzed by the enzymatic method after precipitating serum reagents with phosphotungstic acid and magnesium. LDL-cholesterol (LDL-C) was calculated according to the Friedewald formula (LDL cholesterol = total cholesterol - HDL - (TG/5)) [24]. The cutoff levels used were according to the suggestions of the National Cholesterol Education Program–Adult Treatment Panel III [25]. Dyslipidemia was defined as any hypercholesterolemia: total cholesterol concentration ≥5.2 mmol/L; hypertriglyceridemia with triglyceride concentration ≥1.27 mmol/L; low high-density lipoprotein-cholesterol (HDL-C) concentration ≤0.90 mmol/L; or high low-density lipoprotein-cholesterol (LDL-C) concentration ≥3.5 mmol/L.

Height, weight, and waist and hip circumferences were measured using standard instruments, according to the STEPwise approach [22, 23].

Anthropometric measurements

Body weight and height were measured without shoes, using an electronic measuring scale. Body mass index (BMI) was calculated as weight in kg divided by height in m^2. Waist circumference (WC) was measured, in cm, midway between the lower costal margin and iliac crest during the end-expiratory phase. Hip circumference (HC) was measured, in cm, at the level of the greater trochanters. The waist-to-hip ratio (WHR) was defined as the waist circumference divided by the hip circumference, while the waist/height (WHtR) ratio was defined as the waist circumference divided by the height in cm. The cutoff levels for obesity are as follows, according to WHO and USA standards [22, 23, 26]:

BMI	30+
WHtR	0.5+
WHR	0.90+ for males 0.85 for females, excluding pregnant women
WC	102+ cm for males 88+ cm for females, excluding pregnant women

Data management

Questionnaires collected from the field were reviewed by the team leaders assigned to each team before submitting them to headquarters for data entry. Double entry of the questionnaires was performed using EPI-INFO 2000 software and EpiData software developed by the Menzes Center for validation. After data entry, data cleaning was conducted. New variables were defined by adopting the standard STEPS variables (STEPS Data Management Manual, draft version v1.5, October 2003).

Statistical analysis

The statistical analysis was performed using SPSS for Windows, version 17.0. The data were given as mean ± standard deviation for continuous variable and as counts and percentage for categorical variables. Association between categorical variables was assessed using a chi-square test, and ANOVA was used to compare means of more than two categorical variables. Logistic regression was used to investigate the associations of the binary dependent variable "dyslipidemia" with the independent "obesity" anthropometric measurement variable. Multiple

linear regression analysis was performed to identify significant predictors for serum lipids levels. Level of significance was set at <0.05 throughout the study. The data were processed using SPSS version 17. Totals counts may vary, due to missing data from certain variables.

Ethical clearance and confidentiality

The protocol and the survey instrument were approved by the Ministry of Health, Center of Biomedical Ethics, and the appropriate authorities in KSA. Informed consent of all subjects was obtained. Confidentiality of data was assured, and that data will be used only for the stated purpose of the survey. The survey was conducted in 2005.

RESULTS

Of the 4 990 subjects included in the survey, about 5% (232 subjects) were excluded from final analysis, due to major deficiencies in their data. There were no significant differences between them and the rest of the 4 758 subjects regarding sociodemographic characteristics or obesity status. Table 1 shows age and gender distribution and prevalence of dyslipidemia types according to obesity status as measured by body mass index. About 51% of subjects were females; 23% were less than 25 years of age, and 11% were 55 or more years of age. Dyslipidemia prevalence ranged from about 47% for TG in obese subjects to about 12% for TC among non-obese subjects. Dyslipidemia was higher in males than females and generally increasing significantly with age for all types. Table 2 shows the prevalence of obesity according to the different anthropometric measurements used. Obesity prevalence ranged from 33.8% as measured by WHtR to 40.4% as measured by WHR. Obesity was significantly higher in females than males, except for obesity measured by WHtR, which was significantly higher in males. Table 3 shows prevalence of types of dyslipidemia according to obesity measured by WHR, WHtR, and WC. Prevalence of all types of dyslipidemia was significantly higher among obese subjects, except for HDL dyslipidemia. Table 4 shows that only WHtR was the significant predictor of prevalence for all types of dyslipidemia, as revealed by the multiple logistic regression analysis. Table 5 shows that the mean concentration of all lipids profiles was higher in obese compared to non-obese subjects as measured by all anthropometric measurements. These differences were significant, except for obesity measured by WC for HDL, and measured by WHR except for TG.

Waist for height ratio and Waist circumference were significant predictors of almost all types of serum lipid concentration, as shown by the linear regression analysis in Table 6.

DISCUSSION

Obesity is associated with endothelial dysfunction and greater arterial stiffness from as early as the first decade of life. This effect on vascular function is probably mediated in part by low-grade inflammation, insulin resistance, and production by adipose tissue of cytokine-like molecules, collectively termed adipokines and high leptin concentration [27]. Detecting obesity early by simple and reliable methods can help reverse or reduce these effects. Anthropometric indices, as used in this study, are surrogate measures of body fat. They require no sophisticated equipment or lengthy procedures. They are easy to measure and use, and they are cost-free. Obesity prevalence as assessed by all anthropometric measurements in this study was high, affecting 34–40% of the adult population, and confirming the findings of previous studies [4-6]. The results of this study showed that, in general, anthropometric measures of obesity were significantly correlated with prevalence of dyslipidemia. This finding is in agreement with many national, regional, and international studies [8-19, 28-35]. These studies, including the present study, however, have reported differential association of anthropometric measurements of obesity and prevalence of dyslipidemia type. This study revealed that all dyslipidemia types were significantly associated with obesity, except HDL. Lipid profile concentration for HDL was not significantly associated with obesity as measured by WC, and TG concentration was not significantly associated with obesity as measured by WHR. Only obesity as measured by WHtR was the significant predictor for prevalence of all types of dyslipidemia and lipid profile concentrations. Different anthropometric measures may be better predictors of dyslipidemia, according to populations studied. Significant predictors for dyslipidemia included BMI in a Sudanese study

TABLE 1

PREVALENCE OF DYSLIPIDEMIA ACCORDING TO OBESITY STATUS (MEASURED BY BODY MASS INDEX), GENDER AND AGE OF SUBJECTS

LIPID PROFILE	GENDER N (%)		AGE IN YEAR'S N (%)				
	MALE 2 340 (49.2)	FEMALE 2 418 (50.8)	< 25 1 076 (22.6)	25 - < 35 1 130 (23.7)	35 - < 45 1 167 (24.5)	45 - < 55 841 (17.7)	55+ 544 (11.4)
HIGH TC[A] ≥5.2MMOL/L							
OBESE	324 (22.3)	376 (23.5)	39 (10.1)	125 (17.6)	218 (24.9)	190 (28.5)	128 (31.1)
NOT OBESE	86 (11.7)	78 (11.5)	29 (10.1)	43 (12.8)	30 (13.0)	38 (29.9)	24 (21.1)
*P VALUE	<0.001	<0.001	0.002	0.031	<0.001	0.296	0.022
LOW HDL[B] ≤.90 MMOL/L							
OBESE	517 (35.6)	305 (19.1)	110 (28.4)	202 (28.2)	226 (25.9)	170 (25.5)	114 (27.7)
NOT OBESE	218 (29.7)	98 (14.5)	139 (23.8)	77 (23.0)	43 (18.6)	35 (23.8)	22 (19.5)
*P VALUE	0.003	0.003	0.060	0.038	0.013	0.379	0.047
HIGH TG[C] ≥1.27 MMOL/L							
OBESE	76 (46.8)	537 (33.9)	97 (25.5)	239 (33.8)	358 (41.3)	311 (46.8)	298 (51.0)
NOT OBESE	197 (27.2)	114 (17.1)	92 (16.2)	72 (21.7)	63 (27.4)	47 (32.0)	37 (32.5)
*P VALUE	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
HIGH LDL[D] ≥3.35MMOL/L							
OBESE	511(36.1)	542 (35.0)	74 (20.1)	202 (29.3)	325 (38.4)	278 (42.4)	174 (43.0)
NOT OBESE	146(20.3)	116(17.7)	51(9.1)	70 (21.1)	52 (23.0)	54 (37.2)	35 (31.2)
*P VALUE	<0.001	<0.001	<0.001	0.003	<0.001	0.145	0.016
HIGH TC/HDL[E] ≥5							
OBESE	511 (36.1)	542 (35.0)	74 (20.1)	202 (29.3)	325 (38.4)	278 (42.4)	174 (43.0)
NOT OBESE	146 (20.3)	116 (17.7)	51 (9.1)	70 (21.1)	52 (23.0)	54 (37.2)	35 (31.2)
*P VALUE	<0.001	<0.001	<0.001	0.003	<0.001	0.145	0.016

A=Total cholesterol, B=High density lipoprotein, C=Triglycerides , D=Low density lipoprotein, E=a/b ratio

*P value using Chi square test

TABLE 2

PREVALENCE OF OBESITY USING ANTHROPOMETRIC MEASUREMENTS ACCORDING TO GENDER

OBESITY	MALE N (%)	FEMALE N (%)	TOTAL N (%)	*P VALUE
Body Mass Index ≥30	640 (28.6)	1 017 (43.4)	1 657 (36.1)	<0.001
Waist for Hip ratio Males ≥0.9, Females ≥0.85	1 092 (48.2)	688 (32.1)	1 780 (40.4)	<0.001
Waist Circumference Males≥102 cm, Females≥88 cm	602 (26.6)	912 (42.2)	1 514 (34.2)	<0.001
Waist for Height ratio≥0.5	718 (32.0)	764 (35.6)	1 482 (33.8)	0.008

*P value using Chi square test

TABLE 3

PREVALENCE OF DYSLIPIDEMIA ACCORDING TO ANTHROPOMETRIC MEASUREMENTS N (%)

OBESITY/ DYSLIPIDEMIA	TC[A] ≥5.2MMOL/L	HDL[B] ≤0.90	TG[C] ≥1.27 MMOL/	LDL[D] ≥3.35MMOL/L	TC/HDL[E] ≥5
WAIST / HEIGHT					
OBESE	668 (23.2)	788 (27.4)	1 202 (42.1)	1 046 (37.3)	832 (29.0)
MALES ≥0.9,	126 (9.0)	334 (24.0)	248 (18.1)	206 (15.3)	214 (15.4)
FEMALES ≥0.85	3.05	1.20	3.30	3.30	2.25
NOT OBESE	(2.49-3.73)	(1.03 –1.39)	(2.82-3.86)	(2.79 -3.90)	(1.90- 2.66)
ODDS RATIO	<0.001	<0.009	<0.001	<0.001	<0.001
95% C.I.					
*P VALUE					
WAIST/ HIP					
OBESE RATIO≥0.5	243 (25.4)	237 (24.8)	350 (37.2)	366 (39.4)	268 (28.0)
NOT OBESE	550 (16.1)	882 (20.6)	1 097 (33.3)	883 (27.3)	775 (23.4)
ODDS RATIO	1.72	0.91	1.18	1.73	1.28
95% C.I.	(1.44 -2.04)	(0.77-1.07)	(1.02 -1.38)	(1.49-2.02)	(1.09 – 1.50)
*P VALUE	<0.001	0.142	0.028	<0.001	0.002
WAIST CIRCUMFERENCE					
OBESE	378 (25.3)	405 (27.1)	668 (44.9)	568 (39.1)	441 (21.7)
MALES≥102CM,	417 (15.0)	718 (25.7)	786 (28.5)	686 (25.3)	606 (21.7)
FEMALES≥88CM	1.93	1.07	2.05	1.89	1.51
NOT OBESE	(1.65 – 2.25)	(0.93 –1.24)	(1.79 -2.34)	(1.65 – 1.75)	(1.31 -1.75)
ODD RATIO	<0.001	0.171	<0.001	<0.001	<0.001
95% C.I.					
*P VALUE					

A=Total cholesterol, B=High density lipoprotein, C=Triglycerides , D=Low density lipoprotein,
E=a/b ratio
*P value using Chi square test

[32], WC in Greek and Canadian studies [36, 37], and WHR appeared to be the most suitable predictor of dyslipidemia in a study among Arabs and Asians in Kuwait [38]. Therefore, it appears that the best anthropometric index varies according to study design, geographic area, characteristics of the study population, and the outcome assessed. Higher prevalence of dyslipidemia, except HDL, was significantly associated with higher BMI in this study. Logistic regression analysis, however, showed that BMI was not a significant predictor for dyslipidemia prevalence. Body mass index was not significantly associated dyslipidemia in some studies [39, 40], and decreasing dyslipidemia prevalence was observed with increasing BMI in another study, which was difficult to explain [41]. Body mass index is the most common indicator used for obesity; it does not reflect body fat distribution or distinguish between the accumulations of lean or fat mass. In addition, BMI is less sensitive to changes in lifestyle patterns than measures of abdominal obesity. Reduction of calorie intake and increased physical activity cause a reduction of body fat, paralleled by an increase in muscle mass, resulting in marked changes in measures of abdominal obesity, but no or little change in BMI [42, 43]. Multiple studies have recently attempted to compare BMI with other anthropometric measures of obesity. The findings of the present study agree with the evidence that abdominal fat is a stronger predictor of blood lipids than overall body size as measured by BMI, as abdominal adiposity can vary greatly at a given BMI. In a meta-analysis of

TABLE 4

MULTIPLE LOGISTIC REGRESSION ANALYSIS FOR ANTHROPOMETRIC PREDICTORS OF DYSLIPIDEMIA

ANTHROPOMETRICS/LIPIDS REGRESSION RESULT	WAIST / HIP RATIO	WAIST/ HEIGHT RATIO	WAIST CIRCUMFERENCE	BODY MASS INDEX
TRIGLYCERIDES ≥1.27 MMOL/L				
ODD RATIO	0.84	2.95	1.35	0.96
95% C.I. FOR O.R.[A]	0.72-0.99	2.47-3.52	1.13-1.62	0.82-1.13
P VALUE				
BOTH MALES & FEMALES	0.042	<0.001	<0.001	0.653
MALES	0.542	0.001	0.069	0.640
FEMALES	0.599	0.001	0.001	0.897
TOTAL CHOLESTEROL ≥5.2MMOL/L				
ODD RATIO	1.34	2.64	1.21	0.97
95% C.I. FOR O.R.[A]	1.11-1.60	2.11-3.31	0.99-1.49	0.80-1.18
P VALUE				
BOTH MALES & FEMALES	0.002	<0.001	0.069	0.754
MALES	0.023	0.001	0.175	0.620
FEMALES	0.002	0.018	0.002	0.915
HIGH DENSITY LIPOPROTEIN ≤0.90 MMOL/L				
ODD RATIO	0.855	1.23	1.043	0.93
95% C.I. FOR O.R. [A]	0.72-1.02	1.04-1.46	0.86-1.27	0.78-1.11
P VALUE				
BOTH MALES & FEMALES	0.855	0.018	0.669	0.437
MALES	0.182	0.064	0.801	0.018
FEMALES	0.033	0.012	0.013	0.413
LOW DENSITY LIPOPROTEIN ≥3.35MMOL/L				
ODD RATIO	1.35	2.96	1.08	1.02
95% C.I. FOR O.R.[A]	1.14-1.59	2.46-3.57	0.90-1.30	0.86-1.20
P VALUE				
BOTH MALES & FEMALES	<0.001	<0.001	0.398	0.648
MALES	0.001	0.001	0.001	0.720
FEMALES	0.111	0.001	0.007	0.980
TOTAL CHOLESTEROL/ HIGH DENSITY LIPOPROTEIN ≥5				
ODD RATIO	1.06	2.16	1.06	0.98
95% C.I. FOR O.R.[A]	0.89-1.26	1.79-2.61	0.88-1.28	0.82-1.16
P VALUE				
BOTH MALES & FEMALES	0.524	<0.001	0.551	0.824
MALES	0.001	0.001	0.148	0.902
FEMALES	0.012	0.771	0.007	0.351

95% C.I. for O.R.[A] =95% confidence interval for Odds Ratio

obesity indices comparing BMI, WC, WHR, and WHtR, researchers concluded that WHtR was the best predictor for dyslipidemia for both men and women, while BMI was the least accurate [44]. Statistical evidence supports the superiority of measures of centralized obesity over BMI for detecting cardiovascular risk factors in both men and women [45]. This study showed that almost all obesity measures were significantly associated with dyslipidemia prevalence. Only waist circumference and WHtR were significant predictors for all types of dyslipidemia prevalence and all lipid concentrations. Our finding that WHtR was the only predictor for all dyslipidemia types agrees with the findings of several cross-sectional studies that have shown that WHtR

TABLE 5

MEAN CONCENTRATION (MMOL/L) OF LIPID PROFILE ACCORDING TO ANTHROPOMETRIC MEASUREMENTS

OBESITY/ DYSLIPIDEMIA	[A]TC [F]M(SD)	[B]HDL [F]M(SD)	[C]TG [F]M(SD)	[D]LDL [F]M(SD)	[E]TC/HDL [F]M(SD)
BODY MASS INDEX					
OBESE ≥30	4.65 (1.22)	1.42 (0.09)	1.77 (1.03)	2.89 (1.25)	4.24 (2.39)
NOT OBESE	43.7 (1.14)	1.34 (0.07)	1.55 (0.90)	2.73 (1.16)	4.00 (2.19)
*P VALUE	<0.001	0.002	<0.001	<0.001	<0.001
WAIST / HEIGHT RATIO					
OBESE ≥0.5	4.62 (1.14)	1.31 (0.09)	1.78 (1.05)	2.95 (1.18)	4.37 (2.31)
NOT OBESE	4.10 (1.10)	1.44 (010)	1.31 (0.90)	2.40 (1.08)	3.56 (2.09)
*P VALUE	<0.001	<0.001	<0.001	<0.001	<0.001
WAIST/ HIP RATIO					
OBESE MALES ≥0.9, FEMALES ≥0.85	4.60 (1.24)	1.28 (0.07)	1.65 (0.10)	3.00 (1.18)	4.34 (2.29)
NOT OBESE	4.40 (1.12)	1.18 (0.09)	1.62 (0.90)	2.70 (1.17)	4.03 (2.25)
*P VALUE	<0.001	<0.001	0.444	<0.001	<0.001
WAIST CIRCUMFERENCE					
OBESE MALES≥102CM, FEMALES≥88CM	4.68 (1.15)	1.32 (0.09)	1.82 (1.03)	3.00 (1.17)	4.42 (2.41)
NOT OBESE	1.43 (1.63)	1.37 (0.09)	1.53 (0.10)	2.65 (1.10)	3.93 (2.17)
*P VALUE	<0.001	0.063	<0.001	<0.001	<0.001

A=Total cholesterol, B=High density lipoprotein, C=Triglycerides, D=Low density lipoprotein, E=a/b ratio, [F]M(SD): Mean concentration in millimoles per liter (Standard Deviation)
*P value using ANOVA

best indicates the presence of cardiovascular risk factors, such as dyslipidemia [46, 47]. The WHtR was found to be significantly better than WC for indicating diabetes, hypertension, CVD, and all outcomes (P<0.005) among adults. There is robust statistical evidence from studies involving more than 300 000 adults in several ethnic groups, showing the superiority of WHtR over WC and BMI for detecting cardiometabolic risk factors in both sexes. The WHtR may be a more useful global clinical screening indicator for many other chronic diseases, such as diabetes mellitus and hypertension, supporting the simple public health message "Keep your waist circumference to less than half your height" [48]. The results of recent studies encourage the use of WHtR by General Practioners as an important tool in predicting CV risk [49], but its use for clinical decisions needs further study and robust evidence. The message from this study is that WHtR is the best anthropometric indicator to be used among adults in KSA. It can be utilized in all health care facilities, particularly PHCCs, for initial screening for dyslipidemia and other chronic diseases. The necessary equipment is available in these facilities, and all nurses and nutrition technicians are trained to measure WHtR.

Study limitations

This study is cross-sectional in nature; therefore, all the limitations of such studies are expected to have their effects. The causal association and the definite prediction of dyslipidemia by anthropometric measurements may be questionable. The study population was limited to the 15–64 age group per the

TABLE 6

LINEAR REGRESSION ANALYSIS OF ANTHROPOMETRIC PREDICTORS OF LIPID LEVELS (MMOL/L) (P VALUE)

ANTHROPOMETRICS/LIPIDS REGRESSION RESULT	TG[C]	TC[A]	HDL[B]	LDL[D]	TC/HDL[E]
WAIST / HIP RATIO					
BETA	-0.025	-0.053	-0.082	0.008	0.051
P VALUE	0.176	0.005	<0.001	0.680	0.006
BODY MASS INDEX					
BETA	0.025	0.019	0.073	-0.035	0.003
P VALUE	0.209	0.336	<0.001	0.082	0.869
WAIST CIRCUMFERENCE					
BETA	0.391	0.079	-0.187	0.137	0.359
P VALUE	<0.001	0.110	<0.001	0.006	<0.001
WAIST /HEIGHT RATIO					
BETA	-0.153	0.140	0.096	0.098	-0.194
P VALUE	0.004	0.008	0.071	0.064	<0.001

A=Total cholesterol, B=High density lipoprotein, C=Triglycerides, D=Low density lipoprotein, E=a/b ratio

STEPwise protocol. In addition, the results may have been confounded by other factors, such as medication, nutrition, lifestyle habits, and chronic comorbidity.

CONCLUSIONS

This study revealed that dyslipidemia is prevalent among adults in KSA, is higher in males, significantly increases with age, and is significantly associated with obesity. Body mass index was not a predictor for any type of dyslipidemia. Waist/height ratio was the significant predictor for all types of dyslipidemias, and its use is recommended for screening and followup of dyslipidemic patients. It is easy, inexpensive, and can be used by all health team members, as well as other persons, with minimal training.

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