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Screening of Serum Cholesterol Level Amongst Sri Lankan Women in Relation to Waist-Height Ratio (WHtR), Waist Circumference (WC), Body Mass Index (BMI), Waist-Hip Ratio (WHR), and Waist-Thigh Ratio (WTR): A Cross-Sectional Study

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Abstract

Anthropometric measurements give a general reflection of any changes in lipid concentration in the human body. A disturbed lipid profile can be associated with cardiovascular disease risk. Therefore, this study aimed to investigate the relationship between serum total cholesterol level and different anthropometric parameters related to obesity in a female population of two administrative areas in the Southern Province of Sri Lanka. Analytical cross-sectional study was conducted in Boral and Hiththatiya-Meda areas of Matara district, Sri Lanka. The systematic random sampling method was followed to select 314 females aged 18-60 years. Serum total cholesterol concentration was measured on a venous blood sample by Konelab 20XT biochemistry analyser with a commercially available reagent kit. Body Mass Index (BMI), Waist-Height Ratio (WHtR), Waist Circumference (WC), Waist-Hip Ratio (WHR), and Waist-Thigh Ratio (WTR) parameters were calculated for each individual. Pearson correlation test, chi-squared test and t-test were done to analyse data using SPSS, 16 ($P<0.05$). The serum total cholesterol concentration is positively associated with abdominal obesity while showing a statistically significant positive correlation with BMI, WC, WHR, WTR and WHtR (r=0.217, r=0.590, r=0.315, r=0.347 and r=0.574 respectively; $P\leq0.05$). The prevalence of hypercholesterolemia in the population was 8.6%. These results indicate that all main anthropometric parameters of this study are positively associated with serum total cholesterol levels and an increment of these risk markers can lead to an increase in risk of developing metabolic diseases associated with abdominal obesity among women.

Keywords: Waist-Height Ratio, Waist Circumference, Waist-Hip Ratio, Waist-Thigh Ratio, Obesity, Serum Total Cholesterol

Introduction

High cholesterol concentration, obesity, and diabetes are prevalent among both genders nowadays when compared to the past decades [1]. Though the average total serum cholesterol level is significantly higher in overweight subjects than in lean ones, many obese patients have normal serum lipid concentrations as well. The recommended healthy value of total cholesterol level is <200 mg/dL [2]. Low risk and high risk levels are 200-239 mg/dL and ≥ 240 mg/dL, respectively [2]. Hypercholesterolemia and obesity are known to be associated with development of ischemic heart disease [3]. Anthropometric parameters such as body mass index (BMI), waist circumference (WC), waist-hip ratio (WHR) and waist-height ratio (WHtR) have become a popular tool for assessing obesity, fat patterns and fat distribution in population studies. Several studies have made attempts to compare anthropometric measurements with metabolic parameters or diseases and most studies have used more than one anthropometric parameter to assess abdominal obesity [4]. Therefore, using different anthropometric variables to estimate obesity provides different interpretations and physiological significance [5]. A lower prevalence of anaemia was reported in a study conducted among women aged 20-50 in the Matara district of Southern province, Sri Lanka [6]. Therefore, participants from the same district were selected for the present study to screen the attributes with hypercholesterolemia and to assess the obesity using five different anthropometric parameters (BMI, WC, WHR, WHtR and WTR).

Materials and Methods

Borala and Hiththatiya Meda administrative areas were selected as rural and semi-urban areas respectively in this analytical cross-sectional study. The sample size was 314 and 157 volunteers from each area were selected. The systematic random sampling method was followed. The nature of the study was fully explained to the participants and written consent was obtained. Females between 18-60 years of age in every third family in the "grama niladhari" (local government agent unit) list who gave consent were selected. Females who have chronic diseases and acute infections and those on drugs that affect lipids as well as those who are pregnant were excluded. The study procedure was conducted in accordance with the ethical standards of the Declaration of Helsinki. Prior to data collection ethical approval was obtained (Approval number - 47/15). The privacy of the study participants and the confidentiality of data provided by them were completely protected.

Blood collection and laboratory analysis

This study was done on two consecutive days for obtaining the consent (Day 1) and for withdrawing of blood (Day 2) since the study required 8-10 hours of fasting before blood collection. After obtaining the consent anthropometric measurements were taken on the same day and the following day, venous blood was drawn by a trained nurse with experience in phlebotomy. Serum was separated from whole blood by centrifugation within two hours of blood collection and the separated serum samples were transported at 4°C to the laboratory for analysis of serum cholesterol. The concentration of total serum cholesterol was analysed using the Konelab 20XT biochemistry analyser (Thermo Fisher Scientific Oy, Finland) with a CHOLESTEROL CHOD PAP reagent kit (BIOLABO, France).

Anthropometric measurements

After explaining the procedure, volunteer consent was obtained from the participants and anthropometric measurements were taken. For the calculation of BMI, WHR and WTR, height (m), weight (kg), waist (cm) and thigh circumferences (cm) of each individual were measured. Height was measured using a measuring tape and recorded to the nearest 0.1 cm with the subject looking straight ahead with shoulder blades, buttocks and heels touching a vertical measurement surface and with straight legs and knees together with the head poisoned in the Frankfurt Horizontal plane. According to WHO protocol, waist circumference was measured at the approximate midpoint between the lower margin of the least palpable rib and the top of the iliac crest in the mid axillary line, using a measuring tape [7]. Thigh circumference was measured according to the National Health and Nutrition Examination Survey (NHANES) guidelines [8].

Statistical analysis

Statistical analysis was carried out using SPSS for windows; version 16.0. Pearson correlation test, Spearman correlation test and Pearson chi-square test were used to determine the correlations and associations between the study variables as appropriate. The t-test was used to compare the mean values of study variables in two administrative areas. A *P*-value of <0.05 was taken as the significant probability level.

Results and Discussion

Demographic characteristics of the study population

The age of the study population ranged from 18-60 years. The average age of the subjects was 45 years. More than 50% (209/314) of the study sample was in the 38-60 year age group. When considering civil status, more than 75% (255/314) of the study population was married in both areas, and out of the married population, more than 50% (135/255) of the total population was having one or two children. The working population in the study sample was 44.6%. The working population was higher in Hiththatiya-Meda (54.8%) when compared to Borala (34.4%). It showed that more than 50% (195/314) of the study population did not engage in any physical activities, but 34.4% (108/314) of the study population concerned about their diet with the aim of controlling obesity and cholesterol.

General characteristics of the study population

As given in Table 1, the mean values of serum total cholesterol levels in both areas were less than the hypercholesterolemia level (<240 mg/dL). According to the t-test analysis, there were statistically significant differences in WHR and WTR between the two administrative areas. Mean values of BMI and WC in both areas were in the healthy range whilst mean values of WHR, WHtR and WTR were higher than the reference range in both areas.

Table 1: General characteristics of the study population

Variable	Healthy cutoff point	Mean ± Standard Deviation			*P*-value
		Borala (n=157)	Hiththatiya Meda (n=157)	Total population (n=314)	
Weight (kg)	-	53.73±10.34	53.30±9.65	53.52±9.99	0.713
Height (m)	-	1.51±0.07	1.50±0.07	1.51±0.07	0.882
BMI (kg/m^2)	18·5–22.9	23.9±5.21	23.7±5.02	23.8±5.11	0.820
WC (cm)	≤80.0	80.0±11.40	78.9±10.21	79.5±10.82	0.354
WHR	≤0.80	0.85±0.05	0.82±0.07	0.84±0.06	0.002*
WHtR	≤0.50	0.53±0.08	0.53±0.07	0.53±7.94	0.440
WTR	<1.65	1.80±0.29	1.70±0.31	1.75±0.30	0.010*
Total Cholesterol (mg/dL)	<240	180.9±31.8	183.1±39.8	182.0±35.9	0.584

*Significant at <0.05 level

Prevalence of obesity and hypercholesterolemia in the study population

As per the Pearson chi-square test results (Table 2), there was no significant difference in the prevalence of hypercholesterolemia in the two areas. The prevalence of hypercholesterolemia in the study population was 8.6% (27/314). There was a significant difference in general obesity in both administrative areas (*P*=0.000) but no significant difference was found in central obesity by any of the anthropometric measures (WC, WHR, WHtR and WTR) in both areas. The prevalence of general and abdominal obesity in the study population was 20.1% (63/314) and 50.6% (159/314) respectively.

Table 2: Prevalence of obesity and hypercholesterolemia of the study population

Criterion	Prevalence in Borala (%)	Prevalence in Hiththatiya Meda (%)	Prevalence in Total Population (%)	*P*-value
Hypercholesterolemia	4.5	12.7	8.6	0.759
General Obesity (BMI)	21.0	19.1	20.1	0.000*
Central Obesity (WC)	51.6	49.7	50.6	0.426

*Significant at <0.05 level

Correlation between serum total cholesterol levels and anthropometric parameters

As given in Table 3, all the anthropometric parameters showed a significant positive relationship with serum total cholesterol according to Pearson correlation (r-value>0). According to the Pearson chi-square test, a statistically significant association was observed in all the anthropometric parameters with serum total cholesterol levels (*P*-value<0.05).

Table 3: Correlation between serum total cholesterol levels and anthropometric parameters

Correlation	Pearson Correlation Test	
	P-value	r-value
WC with serum total cholesterol level	0.000*	0.590
WHR with serum total cholesterol level	0.000*	0.315
BMI with serum total cholesterol level	0.000*	0.217
WHtR with serum total cholesterol level	0.000*	0.574
WTR with serum total cholesterol level	0.000*	0.347

*Significant at <0.05 level

Correlation between obesity and total cholesterol level

According to the Spearman correlation test, Table 4 showed a significant positive correlation between serum total cholesterol level and abdominal obesity as assessed by the WC, WHR, WHtR and WTR. A significant positive correlation was observed between serum total cholesterol level and general obesity related to BMI (r-value>0, *P*-value<0.05).

Table 4: Association between obesity and total cholesterol (TC) level

Criteria	Total population (n=314)			Spearman correlation
	Normal TC <200 mg/dL	Low TC 200-239 mg/dL	High TC ≥ 240 mg/dL	
Abdominal obesity				
WC ≥80.0 cm	25.2%	17.2%	8.2%	r = 0.487
WC<80.0 cm	46.2%	2.9%	0.3%	*P* = 0.000*
WHR ≥0.8	50.0%	17.5%	8.0%	r = 0.200
WHR<0.8	21.3%	2.5%	0.7%	*P* = 0.000*
WHtR≥0.50	35.0%	17.5%	8.2%	r = 0.381
WHtR<0.50	36.5%	2.5%	0.3%	*P* = 0.000*
WTR ≥1.65	40.8%	17.2%	7.6%	r = 0.280
WTR <1.65	35.0%	2.9%	1.0%	*P* = 0.000*
General obesity				
BMI ≥27.5 kg/m^2	12.5%	5.1%	3.8%	r = 0.170
BMI<27.49 kg/m^2	59.1%	14.7%	4.8%	*P* = 0.003*

*Significant at <0.05 level

According to socio-demographic background data, the majority of the study sample represented the age group 38-60 years. This study reported high prevalence of obesity among older women. The decrease in the level of physical activity, a sedentary lifestyle, and a higher intake of energy-dense foods as the age of women advances could be the possible explanation [9]. Like in other studies obesity was more common among married women [10]. Married women are likely to have a higher parity which could be linked to adopting a more sedentary lifestyle and high energy foods are usually offered to women during the postpartum period, all having the potential to make them obese.

When considering the results obtained from the present study, the prevalence of hypercholesterolemia in the total population was 8.6% when the cut-off point of hypercholesterolemia was defined as ≥240 mg/dL. A low prevalence of hypercholesterolemia was observed in the two study areas. These values are different from similar studies carried out in Sri Lanka and show a considerably very low prevalence than those findings [1, 11]. According to a study in Galle, Sri Lanka, 63% of female participants were hypercholesterolemic [11]. Another cross-sectional survey conducted in a defined population in the Central province of Sri Lanka reported 12.6% of prevalence of hypercholesterolemia [1]. However, it was conducted among a sample of 975 middle-aged males (35–59 years) [1]. In the present study, the prevalence of general and abdominal obesity (related to WC) in the total population shows a considerably high prevalence than the findings of similar studies conducted in Sri Lanka [12, 13]. A recent study reported that the prevalence of general and abdominal obesity among adolescents in Sri Lanka was 9.2% and 26.2% [12]. Another study reported 6.6% of general obesity and 47% of abdominal obesity among females between 20-50 years of age [13].

According to the literature, associations of general obesity (BMI ≥ 27.5 kg/m2) with chronic diseases and reduced life expectancy have been well documented [14, 15]. In the present study, BMI showed a statistically significant weak positive correlation with cholesterol (r=0.217, *P*=0.000) and a positive correlation with general obesity (r=0.170, *P*=0.003) among women. However, those findings slightly deviate from the studies conducted among North Iranian and white American women where it was shown that the association between hypercholesterolemia and BMI became significantly weaker in high age groups [16, 17].

The present study showed a significantly positive relationship between serum cholesterol level and WC according to the Pearson correlation test (r=0.590, *P*=0.000). This was similarly reported in another study which showed that in both sexes the prevalence of dyslipidaemia (hypercholesterolemia, high LDL cholesterol or low HDL cholesterol level, or hypertriglyceridemia) tended to be higher in subjects with high WC values compared with those with normal WC values [18]. In addition, a study conducted in China reported that overweight women with a high waist circumference were between two and four times as likely to have hypertension, type 2 diabetes, hypercholesterolemia, and metabolic syndrome than overweight women with a low waist circumference [19]. The underlying basis might be that WC has a stronger relationship with adipose tissue distribution than BMI, making WC a better anthropometric marker most associated with adverse blood lipid profile that accompanies excess adiposity [20].

WHR showed a significant positive correlation with cholesterol concentration in this study (r=0.315, *P*=0.000). Another study on WHR across the socio-demographic groups reported that those with a higher WHR were more likely to have hypertension and diabetes (*P*=0.003 and *P*=0.002 respectively) but chronic conditions like stroke and transient ischemic attack were not significantly related to BMI and WHR [21]. Relationship between WHR, especially with hypercholesterolemia is not mentioned in other studies.

WHtR showed a significant strong correlation with cholesterol concentration (r=0.574, *P*=0.000). A study conducted in Europe reported a correlation between WHtR and coronary heart disease risk in women. It showed that WHtR is a significant predictor of hypertension and dyslipidaemia in the coastal (but only for hypertension in the inland area), and in urban settlements (in rural only for hypertension) [22]. A study conducted in Korea among 1718 participants (male and female), aged 39–72 years reported a positive association between WHtR and the incidence of hypertension and suggested that the WHtR may be a better predictor of incident hypertension [23]. Hence, it was proposed to use WHtR for detecting cardiovascular disease risk.

The present study showed a significant positive correlation between obesity (abdominal and general obesity) and total cholesterol level, according to the Spearman correlation test. Similarly, a study which was conducted in Iran showed an association of total cholesterol level with abdominal obesity (based on WC and WHR), especially in the early middle age in the north of Iran. This association was not significant in men and women after the age of 45 and 35, respectively [24]. In addition, another study showed the strongest effect of obesity (based on BMI) on the risk of hypercholesterolemia in subjects aged 25–39 years [25]. The main limitation of this study is that the physical activity level, dietary food intake and socioeconomic status of participants were not assessed. Further studies, therefore, need to be conducted on a large population.

Conclusion

In conclusion, the present study showed that women aged 18-60 years with higher values of BMI, WC, WHR, WHtR and WTR showed high serum total cholesterol levels as well as obesity. An increment of these risk markers can lead to a risk of developing metabolic diseases associated with abdominal obesity among women. Therefore, the population should be further educated and encouraged to decrease the consumption of fried foods, fast foods, oils and meat and to maintain regular exercise or control their daily working pattern in order to decrease the risk of obesity and consequent health risks. No particular anthropometric measure has yet been generally accepted as being superior to another in assessing the metabolic risk associated with abdominal obesity. According to this study, women with high BMI, WC, WHR, WHtR and WTR reported high cholesterol levels and obesity which can increase the risk of developing metabolic diseases linked with abdominal obesity.

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