Association of Anthropometric Parameters with Lipid Profile among Adult Population of Kaski District, Nepal

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ABSTRACT

Background

Anthropometric parameters of individuals are good at predicting functional impairment, mortality, and future cardiometabolic diseases. The relationship between anthropometric parameters and lipid profiles have been studied in different parts of the world. But to date, no such studies have been conducted in Nepal.

Objective

To investigate the association between anthropometric parameters and lipid profile in the adult population of Kaski district, Nepal.

Method

This study was carried out at Manipal Teaching Hospital, Pokhara, Kaski, Nepal. The fasting lipid profiles were analyzed in a total of 400 subjects aged > 18 years with an automated OCD Vitros 350 dry chemistry analyzer. The Kolmogorov-Smirnov test was used to test the normality of the data. The mean values of fasting lipids were compared within the subjects with different body mass index groups using ANOVA and waist circumference, waist-hip ratios, waist-height ratios, and neck circumference using independent samples t-test. The anthropometric indices evaluated were body mass index, waist circumference, waist-hip ratio, waist-height ratio, head circumference, neck circumference, and mid-upper arm circumference. Pearson's correlation coefficients and multiple regression analysis were performed to identify the association between the lipid profile and anthropometric parameters. The difference was considered statistically significant when p values (two-tailed) were < 0.050.

Result

The mean values of the serum lipid parameters other than high-density lipoprotein cholesterol were found to be higher in the subjects with an above than normal BMI, waist circumference, waist-hip ratio, waist-height ratio, and neck circumference. Pearson's correlation coefficient and multiple regression analysis showed that waist-height ratio best predicts serum triglycerides ($\beta=0.622$, $p < 0.001$) and high-density lipoprotein cholesterol ($\beta=-0.711$, $p < 0.001$) among all measured anthropometric parameters.

Conclusion

Among all the studied anthropometric parameters, the WHtR was found to be the most powerful predictor of serum triglycerides and high-density lipoprotein cholesterol.

KEY WORDS

Anthropometry, Association, Dry chemistry, Lipid profile

INTRODUCTION

Anthropometric parameters are simple, safe, and cost-effective tools to measure the amount of obesity.[1] According to the WHO, obesity is an abnormal accumulation of fat that affects health. The number of obese patients has increased significantly, making obesity a worldwide epidemic.[2] The excess adipose tissue, mostly abdominal, is linked to a high prevalence of cardiovascular disease (CVD).[3] Obesity causes dyslipidemia where there are elevations of triglycerides (TG), production of low-density lipoprotein cholesterol (LDL-C) particles, and reduced high-density lipoprotein cholesterol (HDL-C). These abnormalities affect insulin resistance and lipid metabolism; apoprotein production and lipoprotein lipase regulation.[4] Thus, dyslipidemia of obesity results in an adverse cardiovascular risk resulting in a high incidence of cardiovascular morbidity and mortality.

Various tools are used to measure the distribution and amount of body fat and show its relationship to CVDs. The most commonly used measure of body size is the body mass index (BMI), which is related to weight and height. Other anthropometric indices alternatives to BMI are waist circumference (WC), waist-height ratio (WHtR), waist-hip ratio (WHpR), and neck circumference (NC). WC is one of the best anthropometric parameters that indicate abdominal obesity and risk factors for cardiometabolic diseases.[5,6] NC is a sign of subcutaneous (SC) adipose tissue distribution in the upper body part. Upper body SC fat releases more free fatty acid than lower and is linked to disorders like glucose intolerance, hypertriglyceridemia, diabetes mellitus, etc.[7]

The association between the lipid profile and anthropometric parameters is well established in various studies.[8-10] In Nepal, there is a lack of relevant information regarding the selection of the anthropometric parameters that can be used in medical practice and epidemiological studies as the best link to the lipid profile. There have been few studies in Nepal that investigate an association between major anthropometric parameters and lipid profiles among the adult population of Nepal.[11] For this very reason, the extent of association between them always has to be extrapolated from the data obtained from studies conducted elsewhere which may not be always applicable. Moreover, the physical structure, dietary habits, lifestyles, and genetic makeup of the Nepalese population are different from foreign subjects, taking such data as a reference for local use can lead to a huge range of errors.[12] In this context, the present study was carried out to explore whether the major anthropometric parameters could predict one or more components of the lipid profile and serve as simple, safe, and cost-effective surrogate markers. Identification of such surrogate markers could potentially benefit both the patients and clinicians for the better prevention, diagnosis, and monitoring of the treatment of lipid abnormalities in the adult Nepalese population. This study will also provide baseline data and pave the way for a nationwide large-scale cohort study.

METHODS

This is a hospital-based descriptive cross-sectional study conducted at the Manipal Teaching Hospital, Kaski, Nepal from August 2020 to March 2021. A total of 400 adult subjects aged > 18 years of Kaski district, Nepal visiting the Outpatient Department (OPD) of Manipal Teaching Hospital, either as a patient or patient's attendees were included in this study using the convenient sampling method. Subjects with chronic glucometabolic diseases, abdominal distension, pregnancy, intensive care unit (ICU) admission, or no interest to participate were excluded from this study.

Ethical clearance was obtained from the Institutional Ethics and Research Committee of Manipal College of Medical Sciences and Teaching Hospital, Nepal. Informed written consent was obtained from each study subject. Guarantee of absolute confidentiality and privacy was explained to the subjects, and data was used for study purposes only.

All the study subjects were personally interviewed and data regarding age, sex, dietary, smoking and alcohol intake habits, physical activity, occupation, and medical history were collected through a set of pre-validated questionnaires. The primary anthropometric measurements such as height, weight, waist, hip, head, neck, and mid-upper arm circumference (MUAC) were measured following the standard protocols. Bodyweight was measured using a standard analog weighing scale to the nearest kilogram (kg). Height was measured by asking the subjects to stand upright on the floorboard of the stadiometer.[13] BMI was calculated as weight in kg divided by height in meter square. Based on the WHO guidelines for the South Asians, cut-off points used for BMI classification were: normal weight (18-22.9 Kg/m^2), overweight (23-24.9 Kg/m^2), and obese (≥25 Kg/m^2).[14] The waist, hip, head, neck, and MUAC were measured using a non-stretchable measuring tape to the nearest centimeter (cm). WC was measured halfway between the lower rib margin and the iliac crest. Based on the International Diabetes Federation (IDF) guidelines for Asians, the cut-off point used for WC was 90cm for males and 80 cm for females.[15] Hip circumference was measured at the widest point over the greater trochanters with the leg close together.[16,17] WHpR was calculated by dividing waist by hip and WHO cut-off points used for its classification were 0.90 for males and 0.85 for females.[18] The cut-off point used for WHtR classification was 0.50.[19]

Head circumference (HC) was measured often from 1-2 fingers above the eyebrow to the widest part of the back of the head.[20] NC was measured halfway of the neck, between the mid-cervical spine and mid anterior neck and the cut-off point used for NC was 37 cm for males and 34 cm for females.[21] MUAC was measured at the midway between the shoulder and the elbow.[22] The measurement of all anthropometric parameters was taken with subjects wearing light clothes and with shoes removed. Systolic and diastolic blood pressures were measured with an automated upper arm digital sphygmomanometer (Accumed, Switzerland) in the sitting position after the subject had rested for a minimum of 5 minutes.

Sample collection, processing, and storage

Five ml of venous blood samples were collected from each study subject after the overnight fast of 8-12 hours. The blood samples were collected in a tube with clot activators and centrifuged at 4000 rpm for 10 minutes within 30 minutes of collection. Thus, the sera so obtained were either analyzed immediately or stored at -20°C in a Deep freezer when the immediate analysis was not feasible.

Measurement of biochemical variables

Fasting serum glucose (FBG) and lipid profile parameters such as total cholesterol (TC), triglycerides (TG), and high-density lipoprotein-cholesterol (HDL-C) were measured with a fully automated OCD Vitros 350 dry chemistry analyzer (Johnson and Johnson, UK). Fasting blood glucose was measured by the colorimetric-glucose oxidase/ peroxidase method. Total cholesterol was measured by the colorimetric-cholesterol oxidase/peroxidase method. Triglycerides was measured by colorimetric lipase/ glycerol kinase and HDL-C was measured by the non-HDL precipitation method. Low-density lipoprotein cholesterol (LDL-C) was calculated by using Friedwald's equation: LDL-C=TC-HDL-C-VLDL-C (where VLDL-C=TG/5 when TG is < 400 mg/dl).

Quality control and assurance

Calibration and internal quality control of the instrument were carried out using appropriate calibrators and control sera each time before the samples were analyzed. The regular participation of our lab in External Quality Assurance Services (EQAS) provided by the Christian Medical College, Vellore, India further ensured the reliability of our study results. Moreover, all the samples were analyzed using the same lots of reagent kits to reduce the analytical variation. We also calculated both inter-and intra-assay coefficients of variation (CV%) for each analyte under the study. Inter-assay CV% (reproducibility) for serum fasting TC, TG, HDL-C, and FBG were 3.13, 2.70, 2.40, and 4.20, respectively. Similarly, intra-assay CV% (repeatability) for serum fasting TC, TG, HDL-C, and FBG were 1.48, 0.63, 0.78, and 1.36 respectively. CV% of each analyte were within the acceptable ranges.

The data were first entered into and managed in Microsoft Excel (version 2007) and then transferred to statistical package for social science (SPSS) software version 20 (SPSS, IBM, Chicago, IL) for their statistical analyses. The normality of the data was tested with the Kolmogorov-Smirnov test, and the data were found to be normally distributed. The Groupwise comparison of categorical data was carried out by using the Chi-square test while those of continuous variables were carried out by using the independent samples t-test and ANOVA. The correlation between the lipid profile and anthropometric parameters was tested using Pearson's correlation analysis. The anthropometric parameters that predicted lipid profile were identified using the multiple linear regression analysis. The difference in group means or proportion was considered statistically significant when the p-value (two-tailed) was < 0.050.

RESULTS

The gender-wise baseline data of the study subjects are shown in table 1. Of the 400 subjects, 223 (55.8%) were males and 177 (44.3%) were females. The ages of the subjects ranged from 18-84 years and the mean age (SD) was 46.2 ± 12.3 years. The mean systolic blood pressure (SBP) was 127.0±15.7 mm of Hg and diastolic blood pressure (DBP) was 83.1±10.8 mm of Hg. In general, the mean BMI of the subjects was 26.3±3.9 kg/m^2. Based on WHO guidelines for South Asian populations, there were 73 (18.2%) subjects classified as normal weight, 70 (17.5%) as overweight, and 257 (64.2%) as obese. The mean WC of the subjects was 92.2±9.9 cm and WHpR was 0.96±0.08. The mean WHtR was 0.42±0.06. The mean values of HC, NC, and MUAC were 54.7±2.4 cm, 35.2±3.6 cm, and 29.3±3.6 cm respectively. The mean serum levels of TC, TG, HDL-C, LDL-C, and FBG were 177.5 ± 38.0 mg/dL, 182.4 ±96.9 mg/dL, 41.9 ±10.9 mg/dL, 98.9± 33.5 mg/dL, and 107.9 ± 30.7 mg/dL respectively.

Based on their ethnic background, 181 (45.2%) were Brahmins, 104 (26.0%) were Chhetris, 48 (12.0%) were Mongolians, 30 (7.5%) were Newars, and 37 (9.2%) were Dalits. Among all the subjects, 352 (88.0%) were non-vegetarians and 48 (12.0%) were vegetarians. Most of the subjects were non-smokers (364, 91.0%) and non-alcoholics (285, 71.2%). The mean values of WHpR, FBG, TC, and LDL-C did not differ significantly between males and females (p > 0.050). However, the mean age, SBP, DBP, BMI, WC, WHtR, HC, NC, MUAC, TG, HDL-C, and proportion of alcohol intake, and smoking habits differed significantly between males and females (p < 0.050).

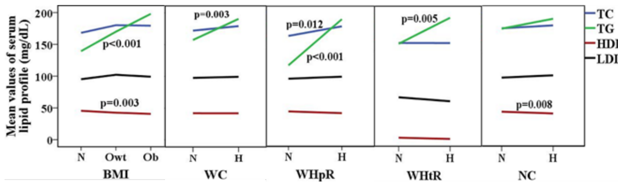
The comparison of mean values of serum lipid profile according to different categories of anthropometric parameters is shown in figure 1. The mean value of serum TC was significantly higher in the subgroup that has higher than the normal WHpR. Likewise, the mean values of serum TG were significantly higher (p < 0.050) in the subgroups of subjects who had higher than the normal BMI, WC, WHpR, and WHtR. On the other hand, the mean value of serum HDL-C was significantly lower (p < 0.050) in the subgroup that had higher than the normal BMI and NC.

The results of Pearson's correlation analysis showing the relationship between anthropometric parameters and serum lipid profile are shown in table 2. The analysis showed a significant positive correlation between BMI and TG. NC, MUAC, WC, WHtR, and WHpR showed a significant positive correlation with TG. WHpR showed a significant

Table 1. Sociodemographic and anthropometric variables of study subjects.

Characteristic Variables	Male	Female	p-value	Total
N (%)	223 (55.8)	177 (44.3)	-	400
Age (years)	47.7±12.9	44.2±11.3	0.005[b]	46.2±12.3
Blood pressure (mm of Hg)				
SBP	129.0±16.3	124.4±14.6	0.004[b]	127.0±15.7
DBP	84.0±10.8	81.8±10.8	0.044[b]	83.1±10.8
BMI (kg/m^2)	25.8±3.6	27.0±4.2	0.002[b]	26.3±3.9
BMI (kg/m^2)				
Normal weight	44 (19.7)	29 (16.4)	0.002[b]	73 (18.2)
Overweight	43 (19.3)	27 (15.3)		70 (17.5)
Obese	136 (61.0)	121 (68.4)		257 (64.2)
WC (cm)	93.2±9.2	91.0±10.7	0.028[b]	92.2±9.9
WHpR	0.98±0.07	0.93±0.08	<0.001[a]	0.96±0.08
WHtR	0.43±0.06	0.41±0.06	0.034[b]	0.42±0.06
HC (cm)	55.2±2.4	54.0±2.3	<0.001[a]	54.7±2.4
NC (cm)	36.4±3.3	33.8±3.4	<0.001[a]	35.2±3.6
MUAC (cm)	29.7±3.8	28.9±3.2	0.032[b]	29.3±3.6
TC (mg/dL)	178.9±38.0	175.7±38.1	0.402[c]	177.5±38.0
TG (mg/dL)	203.3±100.8	155.9±85.1	<0.001[a]	182.4±96.9
HDL-C (mg/dL)	39.4±10.9	45.0±10.0	<0.001[a]	41.9±10.9
LDL-C (mg/dL)	98.5±34.1	99.5±32.9	0.759[c]	98.9±33.5
FBG (mg/dL)	108.9±28.7	106.6±33.2	0.462[c]	107.9±30.7
Ethnic Group				
Brahmin	101 (45.3)	80 (45.2)	0.586[c]	181 (45.2)
Chhetri	63 (28.3)	41 (23.2)		104 (26.0)
Mongolian	27 (12.1)	21 (11.9)		48 (12.0)
Newar	15 (6.7)	15 (8.5)		30 (7.5)
Dalit	17 (7.6)	20 (11.3)		37 (9.2)
Dietary Habits				
Non-Vegetarian	200 (89.7)	152 (85.9)	0.244[c]	352 (88.0)
Vegetarian	23 (10.3)	25 (14.1)		48 (12.0)
Alcohol Intake				
No	126 (56.5)	159 (89.8)	<0.001[a]	285 (71.2)
Yes	97 (43.5)	18 (10.2)		115 (28.8)
Smoking				
No	192 (86.1)	172 (97.2)	<0.001[a]	364 (91.0)
Yes	31 (13.9)	5 (2.8)		36 (9.0)

The results are presented as mean ± SD for continuous variables and N (%) for categorical variables [a]p < 0.001, [b]p <0.05, [c]p >0.05 (two tailed); groups were compared using Indepen dent samples t-test for quantitative variables and Chi square test for categorical variables. BMI: body mass index, WC: waist circumference, WHpR: waist-hip ratio, WHtR: waist-height ratio, HC: head circumference, NC: neck circumference, MUAC: mid upper arm circumference, TC: total cholesterol, TG: triglycerides, HDL-C: high density lipoprotein cholesterol, LDL-C: low density lipoprotein cholesterol, FBG: fasting blood glucose.



One-way ANOVA was used for comparing serum lipid profile within the three BMI groups (normal, overweight and obese). Independent samples t-test was used to compare the mean values of lipid profile within the group (normal and high) of WC, WHpR, WHtR and NC. N: normal, Owt: overweight, Ob: obese, H: high, BMI: body mass index, WC: waist circumference, WHpR: waist-hip ratio, WHtR: waist-height ratio, NC: neck circumference, TC: total cholesterol, TG: triglycerides, HDL-C: high density lipoprotein cholesterol, LDL-C: low density lipoprotein cholesterol.

Table 2. Correlation of different anthropometric parameters with lipid profile in total subjects.

Anthropometric parameters	TC (mg/dL)	TG (mg/dL)	HDL-C (mg/dL)	LDL-C (mg/dL)
BMI (kg/m^2)	r=0.053	r=0.259**	r=-0.068	r=-0.006
WC (cm)	r=0.072	r=0.448**	r=-0.085	r=-0.043
WHpR	r=0.100*	r=0.406**	r=-0.081	r=-0.030
WHtR	r=0.067	r=0.460**	r=-0.160**	r=-0.019
HC (cm)	r=0.027	r=0.011	r=-0.015	r=0.025
NC (cm)	r=0.032	r=0.199**	r=-0.186**	r=-0.023
MUAC (cm)	r=0.068	r=0.176**	r=-0.095	r=0.013

**correlation is significant at the o.o1 level (2-tailed). *correlation is significant at the o.o5 level (2-tailed). The Pearson's correlation coefficient (r) values of 0 was interpreted as no correlation, r values between ±0.1 and ±0.3 as weak correlations, ±0.4 to ±0.6 as moderate correlations, ±0.7 and ±0.9 as strong correlations, and ±1 was interpreted as perfect correlation. TC: total cholesterol, TG: triglycerides, HDL-C: high density lipoprotein cholesterol, LDL-C: low density lipoprotein cholesterol, BMI: body mass index, WC: waist circumference, WHpR: waist-hip ratio, WHtR: waist-height ratio, HC: head circumference, NC: neck circumference, MUAC: mid upper arm circumference.

positive correlation with TC. NC and WHtR also showed a significant but negative correlation with HDL-C. HC did not show any correlation with lipid profile.

The result of multiple linear regression analysis using the individual lipid profile parameter as the dependent variable and adjusted anthropometric parameters as predictive variables is presented in table 3. BMI (β=0.315, p=0.001), WC (β=0.324, p=0.045), and WHtR (β=0.622, p<0.001) were found to be the significant positive predictors of serum TG levels. Likewise, BMI (β=-0.440, p=0.001), WC (β=-0.259, p=0.033), and WHtR (β=-0.711, p<0.001) were found to be the significant negative predictor of serum HDL-C levels. WHpR was a significant positive predictor (β=0.347, p=0.001) of serum TG level. HC was a significant negative predictor (β=-0.106, p=0.039) of serum TG level. NC and MUAC could not predict any of the lipid profile parameters. Among all the predictors identified, the WHtR was found to be the most powerful predictor of serum TG and HDL-C levels which often gets deranged in multiple cardiometabolic diseases and dyslipidemia.

Table 3. Multiple regression analysis of relationship between anthropometric parameters with lipid profiles.

Anthropometric parameters	TC (mg/dL)		TG (mg/dL)		HDL-C (mg/dL)		LDL-C (mg/dL)	
	β	p-value	β	p-value	β	p-value	β	p-value
BMI (kg/m^2)	0.039	0.774	0.315	0.001**	-0.440	0.001**	0.135	0.326
WC (cm)	-0.080	0.525	0.324	0.045*	-0.259	0.033*	-0.093	0.464
WHpR	0.145	0.082	0.347	0.001**	-0.084	0.295	0.050	0.550
WHtR	0.032	0.852	0.622	<0.001***	-0.711	<0.001***	-0.093	0.585
HC (cm)	0.005	0.930	-0.106	0.039*	0.077	0.146	0.037	0.503
NC (cm)	-0.044	0.512	0.006	0.917	-0.115	0.074	-0.027	0.687
MUAC (cm)	0.057	0.385	0.080	0.184	0.026	0.673	0.023	0.722

All models were adjusted by age, cigarette smoking, and alcohol drinking. *=p<0.05, **=p<0.025, ***=p<0.001 (two tailed). TC: total cholesterol, TG: triglycerides, HDL-C: high density lipoprotein cholesterol, LDL-C: low density lipoprotein cholesterol, BMI: body mass index, WC: waist circumference, WHpR: waist-hip ratio, WHtR: waist-height ratio, HC: head circumference, NC: neck circumference, MUAC: mid upper arm circumference.

DISCUSSION

Anthropometric parameters are commonly used as research tools to measure the risk factors for noncommunicable diseases (NCDs) in a population. For many years, dyslipidemia has been considered to be one of the important risk factors for several NCDs such as CVDs, diabetes mellitus, hypertension, etc.[23] However, measuring serum lipid parameters at a certain setup, particularly during a field study or at home is not feasible. A simple, safe, non-invasive and reliable surrogate marker that can accurately predict the serum lipid parameters could potentially avoid the hassle of invasive sampling and measurement on these sites. Anthropometric parameters among others have recently been studied extensively and proposed as potential predictors of serum lipid profile in certain populations.[8,9] However, there has been scanty data on such studies in Nepal. This very research gap had prompted the authors to conduct this study which explored the association of anthropometric parameters with the components of serum lipid profile among the adult population of Kaski District, Nepal.

In the present study mean values of serum TG and HDL-C were significantly different in the different categories of BMI (fig 1). The higher mean values of serum TG in obese subjects in comparison to overweight and normal BMI subjects could be due to increased hepatic production of VLDL particles and a decrease in the clearance of TG-rich lipoproteins in overweight and obese subjects. There was a statistically significant higher mean value of TC and TG in those subgroups that has higher than normal WHpR. These findings were similar to observation reported by Mallick et al.[24]

In the present study, BMI showed a statistically non-significant correlation with TC and LDL-C. This finding was similar to observation reported by Manjareeka et al. and Shamai et al.[23,25] On the contrary, a study by Garg et al. found a significant correlation of BMI with TC and LDL-C.[26] BMI showed a non-significant inverse correlation with HDL-C. Conversely, Shamai et al. reported that BMI showed a significant inverse correlation with HDL-C.[25] There was a significant correlation between BMI and TG. This finding was similar to the observation reported by Garg et al.[26] However, a study done in India reported no correlation between BMI and TG.[23]

WC in the present study showed a statistically non-significant correlation with TC, HDL-C, and LDL-C. On the other hand, a study conducted by Garg et al. reported a significant correlation with TC, HDL-C, and LDL-C.[26] WC in the present study showed a significant correlation with TG. This finding was similar to observation reported by Manjareeka et al. and Garg et al.[23,26]

In the present study, WHpR showed a significant correlation with TC. Comparable findings have been observed in a study by Garg et al.[26] WHpR showed a statistically non-significant correlation with LDL-C and HDL-C. This is consistent with earlier studies where there was significant correlation between WHpR and HDL-C.[23] In our study, WHpR showed a significant correlation with TG. Similar observations have been reported by Garg et al.[26]

WHtR in the present study showed a significant correlation with TG and HDL-C. Comparable findings have been observed in a study done in China.[8]

NC showed a significant correlation with TG and HDL-C. This is because NC is a marker of upper body SC adipose tissue distribution which is correlated to metabolic disorders like glucose intolerance, diabetes mellitus, hypertriglyceridemia, etc. Free fatty acid release from the upper body SC fat is more than that from the lower body. A result of increased free fatty acid flux from adipocytes leads to increased lipid (VLDL and TG) synthesis in hepatocytes.[21]

We analyzed the usefulness of anthropometric parameters as predictors of lipid profile using multiple regression analysis (table 3). BMI was a significant positive predictor of serum TG and a significant negative predictor of serum

HDL-C. This is consistent with earlier studies conducted by Yang et al.[8] WC is a significant positive predictor of serum TG and a significant negative predictor of serum HDL-C. Comparable findings were observed in a study done in Saudi Arabia.[27] WHpR is a significant positive predictor of serum TG. Similar observations have been made by Yang et al.[8] WHtR in the present study is a significant positive predictor of serum TG and a significant negative predictor of serum HDL-C. On the other hand, a study reported that WHtR is a significant negative predictor of serum TG and a significant positive predictor of serum HDL-C.[27]

The results of our research suggest that WHtR best reflects serum TG and HDL-C agrees with the outcomes of numerous cross-sectional studies where WHtR is associated with cardiovascular risk factors such as high TG and low HDL-C.[28,29] The WHtR can be used as a screening tool for CVD, assisting the public health message "Keep your waist circumference to less than half your height".[30] Thus, WHtR can be used as a primary screening tool in predicting risk factors for CVD by medical personnel, however further study is needed to validate its use in clinical decision making.

Our study provided first-hand data on the relationship between anthropometry and serum lipid parameters among the adult Nepalese population and therefore serves as the foundation of a large nationwide study. However, it is not devoid of limitations. It was a single hospital-based cross-sectional study that enrolled subjects hailing from different parts of the Kaski district, Nepal. Moreover, the sample size used was considerably smaller than that is often used in large epidemiologic studies. An even better resolved, statistically powerful, and the generalizable association between anthropometric parameters and lipid profiles could have been evident with a bigger sample size. Hence, our data could be generalized only to the local context and may therefore not be extrapolated to all the adult population of Nepal.

CONCLUSION

The present study identified BMI, NC, WC, WHpR, and WHtR as the potential predictors of the serum lipid profile and thus provided evidence of a relationship between simple anthropometric parameters and serum lipid profile in the Nepalese population too. Among these anthropometric parameters, WHtR was the strongest predictor of serum TG and HDL-C. In a developing country like Nepal, it can be hoped that these simple and non-invasive anthropometric parameters may provide an alternative measure to screening the risk factors of cardio-metabolic diseases at an individual or population level.

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REFERENCES

1. Can AS, Bersot TP, and Gonen M. Anthropometric indices and their relationship with cardiometabolic risk factors in a sample of Turkish adults. *Public Health Nutrition.* 2008;12(4):538–46. doi: 10.1017/S1368980008002474.
2. Unnikrishnan AG, Kalra S, Garg MK. Preventing obesity in India: Weighing the options. Indian J Endocr Metab 2012;16(1):4-6. doi: 10.4103/2230-8210.91174.
3. Mota dos Santos C, Sá Silva C, César de Araújo E, Kruze Grande de Arruda I, da Silva Diniz A, Coelho Cabral P. Lipid and glucose profiles in outpatients and their correlation with anthropometric indices. *Rev Port Cardiol.* 2013;32(1):35-41. doi: 10.1016/j.repce.2012.05.009.
4. Biadgo B, Abebe SM, Baynes HW, Yesuf M, Alemu A, Abebe M. Correlation between Serum Lipid Profile with Anthropometric and Clinical Variables in Patients with Type 2 Diabetes Mellitus. *Ethiop J Health Sci.* 2017;27(3):215-26. doi: 10.4314/ejhs.v27i3.3.
5. Fund I. Development a relationship of waist circumference, waist-hip ratio, and body mass index as predictors of obesity in adult Nigerians. *Pak J Nutr*. 2011;10(1):15-18. doi: /10.3923/pjn.2011.15.18.
6. Bhurosy T, Jeewon R. Pitfalls of using body mass index (BMI) in assessment of obesity risk. *Curr Researc Nutr Food Sci*. 2013;1(1):71-76. doi: 10.12944/CRNFSJ.1.1.07.
7. Khan UK, Dipta TF, Mofaruque, Sarder K, Sultana SSS, Nahar Q. Prevalence of metabolic syndrome in diabetic patient. *J Bangladesh Coll Phys Surg*. 2012;30(2):85-90. doi: 10.3329/jbcps.v30i2.11409.
8. Yang Z, Ding X, Liu J, Duan P, Si L, Wan B, et al. Associations between anthropometric parameters and lipid profiles in Chinese individuals with age ≥ 40 years and BMI < 28 kg/m^2. *PLoS ONE.* 2017 12 (6): e0178343. https://doi.org/10.1371/journal.pone.0178343.
9. Zhang Z-q, He L-p, Xie X-y, Ling W-h, Deng J, Su Y-x et al. Association of Simple Anthropometric Indices and Body Fat with Early Atherosclerosis and Lipid Profiles in Chinese Adults. *PLoS ONE.* 2014; 9(8): e104361. doi:10.1371/journal.pone.0104361.
10. Eke CB, Ogbodo SO, Onyire NB, Muoneke UV, Ukoha MO, Amadi OF, et al. Association of Body Mass Index and Serum Lipid Profile among Adolescents in Enugu, Nigeria. *Ann Med Health Sci Res*. 2018;8:404-10.
11. Baral N, Jha P, Sridhar MG, Karki P, Sharma SK, Khambu B. Association of lipid profile and Body Mass Index (BMI) in hypertensive patients of Eastern Nepal. *J Nep Med Assoc*. 2006; 45 (163): 306-09. doi:10.31729/jnma.416.
12. Awasthi JR, Uprety BN, Mallik SL, Pant P. The best anthropometric index to access the risk of hypertension in the population of Kavre district, *Nepal. Eur. J. Anat.* 2015;19(3):269-75.
13. Lohman TG, Roche AF, Martorell R. Anthropometric Standardization Reference Manual. Champaign II: Human Kinetics; 1988;143-9.
14. World Health Organization. Regional Office for the Western Pacific. The Asia-Pacific perspective: redefining obesity and its treatment. Sydney: Health Communications Australia 2000.

15. Alberti KG, Zimmet P, Shaw J. IDF Epidemiology Task Force Consensus Group The metabolic syndrome-A new worldwide definition. *Lancet*. 2005;366:1059-62. doi: 10.1016/S0140-6736(05)67402-8.

16. Dudeja V, Mistra A, Pandey RM, Devina G, Kumar G, Vikram NK. BMI does not accurately predict overweight in Asian Indians in Northern India. *British J Nutr.* 2001;86 (1): 105-12. doi: 10.1079/bjn2001382.

17. Seidell JC, Perusse L, Despres JP, Bouchard C. Waist & Hip circumferences have independent and opposite effects on cardiovascular disease risk factors: The Quebec family study. *Amer J Clin Nutr.* 2001;74(3):315-21. doi: 10.1093/ajcn/74.3.315.

18. Lear SA, James PT, Ko GT, Kumanyika S. Appropriateness of waist circumference and waist-to-hip ratio cutoffs for different ethnic groups. *Eur. J. Clin. Nutr.* 2010;64:42–61. doi:10.1038/ejcn.2009.70.

19. Peng Y, Li W, Wang Y, Bo J, Chen H. The Cut-Off Point and Boundary Values of Waist-to-Height Ratio as an Indicator for Cardiovascular Risk Factors in Chinese Adults from the PURE Study. *PLoS ONE*. 2015; 10(12): e0144539. doi:10.1371/journal. pone.0144539

20. Ormeci AR, Gürbüz H, Ayata A, Çetin H. Adult Head Circumferences and Centiles. *Journal of Turgut Özal Medical Center*. 1997;4(3):261-64.

21. Aswathappa J, Garg S, Kutty K, Shankar V. Neck Circumference as an Anthropometric Measure of Obesity in Diabetics. *N Am J Med Sci.* 2013;5(1);28–31. doi: 10.4103/1947-2714.106188.

22. Hop LT, Gross R, Sastroamidjojo S, Giay T, and Schultink W. Mid-upper-arm circumference development and its validity in assessment of undernutrition. *Asia pacific J Clin Nutr.* 1998;7(1):65-9. PMID: 24394899.

23. Manjareeka M, Nanda S, Mishra J, Mishra S. Correlation between anthropometry and lipid profile in healthy subjects of Eastern India. *J Mid-life Health.* 2015;6(4):164-68. doi: 10.4103/0976-7800.172302.

24. Mallick AK, Ahsan M, Das B, Rai S. A correlation study of lipid profile with body mass index and waist hip ratio in Rohilkhand region. *Int J Med Res Rev.* 2018;6 (3):186-91. doi: 10.17511/ijmrr.2018.i03.09.

25. Shamai L, Lurix E, Shen M, Novaro GM, Szomstein S, Rosenthal R, Hernandez AV, Asher CR. Association of Body Mass Index and Lipid Profiles: Evaluation of a Broad Spectrum of Body Mass Index Patients Including the Morbidly Obese. *Obes Surg.* 2011;21(1):42-7. doi: 10.1007/s11695-010-0170-7.

26. Garg S, Vinutha S, Karthiyanee K, and Nachal A. Relation between anthropometric measurements and serum lipidprofile among cardio-metabolically healthy subjects: A pilot study. *Indian J Endocrinol Metab*. 2012;16(5):857–8. doi: 10.4103/2230-8210.100686.

27. Saeed AA. Anthropometric predictors of dyslipidemia among adults in Saudi Arabia. *Epidemiol Biostat Public Health*. 2013;10: e 8 7 3 3. doi : 10.2427/8733.

28. Ho SY, Lam TH, Janus ED. Waist to stature ratio is more strongly associated with cardiovascular risk factors than other simple anthropometric indices. *Ann Epidemiol*. 2003; 13 (10): 683-91. doi: 10.1016/s1047-2797(03)00067-x.

29. Hsieh SD, Yoshinaga H, Muto T. Waist-to-height ratio, a simple and practical index for assessing central fat distribution and metabolic risk in Japanese men and women. *Int J Obes Relat Metab Disord*. 2003; 27 (5): 610-6. doi: 10.1038/sj.ijo.0802259.

30. Ashwell M, Gunn P, Gibson S. Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: systematic review and meta-analysis. *Obes Rev*. 2012; 13 (3): 275-86. doi: 10.1111/j.1467-789X.2011.00952.x.