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Research Article

Impact of Body Mass Index on Coronary Morphology

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Keywords
- Body mass index
- Coronary artery
- Body fat
- Over weight

Abstract

Introduction: Asians have lower mean BMI than that of non-Asian populations. There is a lack of sufficient data from Asian countries with WHO consultation to describe either there is an association of BMI with body fat or to CAD. The aim of the study was to correlate the BMI and coronary artery measurements to find out any association between them to be a precursor to CAD. The objective was focused to find the possible association of body mass index (BMI) with normal coronary vessel dimensions.

Materials and Methods: Four thousand angiograms from patients of Indian origin were studied prospectively after procuring the sanction for the same from the ethical committee of the pre-selected hospitals from four states of South India. Patient's anthropometric measurements were done using the fore mentioned relevant equipments. BMI and BSA were calculated. Informed consents were obtained. Post CABG, post PCI patients and patient being diabetic for ≥5 years were excluded from the study.

Results: Among total sample population, normal coronary arteries were seen in 933 (23.3%), cases and 3,067 (76.7%), had diseased coronary arteries. The average weight was 63.19 ± 5.09 kg (range 90.00– 37.00 kg), height was 168.15 ± 4.60cm (range 190.00–135.00 cm). An overall significant negative correlation was observed among 933 cases of normal samples of indexed coronary artery measurements with BMI.

Conclusion: The present study concludes that with increase in BMI, there was a relative decrease in coronary artery diameter. The risk of CAD and associated multimorbidity is directly proportional to BMI.

INTRODUCTION

World health organisation (WHO), recommended that the classifications of bodyweight should be according to the degrees of underweight and gradations of overweight. These degress are associated with an increased risk of some non-communicable diseases [1,2]. A wide range of morbidity and mortality profiles based on social and economic determinants of health along with high risks profiles in certain cases which are observed among Asian population [3]. In contrast, June *et al.* (2002), reports that BMI cutoffs are associated with equivalent risk across ethnic groups even if it differs widely depending on the outcome and the risk estimate [4]. In general, Asians have lower mean BMI than that of non-Asian populations. Most studies assessing the effect of BMI on early clinical outcomes after CABG have compared hospital mortality and morbidity between obese and non-obese patients [5,6]. Many previous attempts to address this problem were limited by small sample sizes or a lack of data about potentially confounding factors [5-7]. There is a lack of sufficient data from Asian countries with WHO consultation to describe either there is an association of BMI with body fat or to CAD. Proper statistically correlated data can aid to predict an increase or decrease in morbidity and mortality rates in populations of Asian countries, or in subgroups within countries.

Cardiovascular risk factors are higher in Asians, a lower BMI cut-off values are recommended for them compared to any other races or countries [3]. This indicates that cardiologists should pay more attention to find out the relationship between BMI and its effect on coronary artery measurements as it seems to have an effect on coronary artery morphology that can effect on patient outcome. Based on BMI, which is calculated as weight in kilograms divided by height in metres squared (kg/m^2), the populations at health risks are classified. BMI cut-off points for overweight and obesity are mainly applicable for policy purposes, to inform and trigger policy action, to facilitate the prevention programmes, and to measure the effect of interventions. The associations between BMI and health outcomes within and across populations are helpful to ascertain the cause of diseases for epidemiological purposes. This can warrant a public health to inform policy, trigger action, facilitate prevention programmes, and to assess the effect of clinical interventions [3]. The relation between BMI and the percentage of body fat depends on age and sex, and it differs across ethnic groups [46,47]. The relative percentage of body fat at different BMIs clearly varies within the populations. This in turn depends upon environmental factors and the amount of physical activity. There are differences in percentage of body fat between rural and urban populations in India. The relations between BMI and body fat implies that the higher percentage of body fat at lower BMIs can result in an increased risk of disease. The aim of the present study was to correlate the BMI and coronary artery measurements to find out any association between them to be a precursor to CAD. The objective was focused to find the possible association of body mass index (BMI) with normal coronary vessel dimensions.

METHODOLOGY

Study population

A cross sectional study was conducted in four cities of India. Hospitals were purposely selected according to the number of cardiac patients identified by them. The age of the study subjects was given a cut-off at 75 years due to marginal benefits marked during the follow-ups. Hence, a conservative approach is proven to be appropriate for the above-mentioned age which itself indicates a poor prognosis with an average yearly mortality rate of 33%–35% [10].The inclusion criteria were all patients who undergo percutaneous coronary angiographic procedure due to abnormalities in the normal cardiac parameters after obtaining their informed consent. Exclusion criteria were patients with a previous history of CABG and recanalized normal looking coronary arteries with or without in-stent restenosis coronary arteries as well as patients being diabetic for five or more than five years. The sample size was estimated by consulting a statistician and using the statistical software G* Power 3.0.10 and 4000 subjects were studied by convenience sampling. All ethical principles for human research were followed and Ethical approval was obtained from the Institutional Ethics Committee of all the hospitals from where data was collected.

Calculation of BMI

a. BMI of a person was calculated as weight in kilograms divided by height in metres squared (kg/m^2). As a measure of relative weight, BMI is easy to obtain. This is an acceptable proxy for thinness and fatness. It is directly related to health risks and death rates in many populations [11].

b. The suggested categories of BMI for Asian populations are as follows

Less than 18·5 kg/m^2 - underweight

18·5–23 kg/m^2 - normal / increasing but acceptable risk

23–27·5 kg/m^2 - overweight / increased risk

27·5 kg/m^2 or more - obesity / higher high risk [12]

Weight of the patients was measured by digital weighing machine with crystal display by Health Genie digital weighing scale HD-221; silver pattern (Manufactured by Health Genie Company). Measured values were recorded as such with decimals without approximating it into highest or lowest decimal values. The height of the patient was measured by the height measuring scale with inches and centimetre calibrations by gadget Hero's height measuring scale/tape/stature meter (200 cm /78 inch), wall mounted type (Manufactured by Gadget Hero's company).

Four thousand QCA reports were collected and studied for the following parameters

i. LMCA and RCA along with its main branches were assessed for the vessel morphology at the ostium and proximal segment among normal cases by stenosis analysis programme. This programme had incorporated an automated coronary analysis package of the Innova 2100 IQ Cath at an AW4.4 workstation or of the Siemens QCA – Scientific coronary analysis. The gender wise categorisation of the data was done to denote the mean differences in the artery measurements.

ii. Patient's anthropometric measurements were done using the fore mentioned relevant equipments. BMI and BSA were calculated. BMI was calculated by the relevant formula weight in kilograms divided by height in metres squared (kg/m^2). BSA was calculated from patient's height and weight measurements using Mosteller's formula. The diameters of the ten segments of coronary artery from angiogram study samples were indexed (adjusted) to BSA (mean diameter mm/m^{2}BSA).

RESULTS

Patient characteristics

Based on QCA analysis, categorisations of 4,000 samples were done. Among total sample population, there were 2,696 (67.4%) males and 1,304 (32.6%) females. Mean age of the patients was 54.50 ± 8.45 years (range 30–75 years). Among total sample population, normal coronary arteries were seen in 933 (23.3%) cases and 3,067 (76.7%) had diseased coronary arteries. Physical and demographic parameters were assessed. The average weight was 63.19 ± 5.09 kg (range 90.00– 37.00 kg), height was 168.15 ± 4.60cm (range 190.00–135.00 cm). BMI of 21 patients including 12 males and 9 females were not assessed due to technical or health issues.

BMI values were correlated with indexed and non-indexed CAM of normal sample population to study the association. An overall significant negative correlation was observed among 933 cases of normal samples of indexed CAM with BMI. Results indicated that as BMI increases; there was a relative decrease in coronary artery diameter. Statistical correlations with BMI among indexed CAM of gender wise categorised samples were noted down. There was a significant negative correlation between indexed CAM and BMI among 509 male samples. However, correlation was not significant among female sample population of 403 cases (Table 1).

Correlation of indexed CAM of normal samples with categorised BMI values shows that (Table 2), indexed normal CAM of the study samples were correlated with BMI cut-off levels for Asian populations [3]. A highly significant correlation was observed in overweight (OW), category of BMI with LMCA, LAD-o, LCx-o. No significant correlations were observed in other segments of indexed CAM with BMI categories. Correlation of BMI with non- indexed CAM in normal samples (n=933), indicated that (Table 3), no significant correlations were observed between non-indexed CAM of normal samples and BMI among total as well

Table 1: Correlation of BMI with indexed CAM in normal samples (n=933).

Indp. Variable	Correlation analysis	NSP	CAS included for correlation analysis									
			LMCA	LAD-o	LAD-p	DIAG	LCX-o	LCX-p	OM	RCA- o	RCA- p	RAM
BMI	r	T	-0.150^{**}	-0.135^{**}	-0.147^{**}	-0.117^{**}	-0.191^{**}	-0.136^{**}	-0.112^{**}	-0.178^{**}	-0.121^{**}	-.135
	p-value		$<0.001^{***}$	$<0.001^{***}$	$<0.001^{***}$	$<0.001^{***}$	$<0.001^{***}$	$<0.001^{***}$	$<0.001^{***}$	$<0.001^{***}$	$<0.001^{***}$	0.177
	r	M	-0.192^{**}	-0.175^{**}	-0.168^{**}	-0.157^{**}	-0.255^{**}	-0.193^{**}	-0.188^{**}	-0.162^{**}	-0.110^{*}	-.107
	p-value		$<0.001^{***}$	$<0.001^{***}$	$<0.001^{***}$	$<0.001^{***}$	$<0.001^{***}$	$<0.001^{***}$	$<0.001^{***}$	$<0.001^{***}$	$<0.02^{*}$	.415
	r	F	-0.122^{*}	-0.106^{*}	-0.134^{**}	-0.084	-0.144^{**}	-0.093	-0.055	-0.197^{**}	-0.133^{**}	-.191
	p-value		$<0.05^{*}$	$<0.04^{*}$	$<0.01^{*}$	0.106	$<0.01^{*}$	0.071	0.295	$<0.001^{***}$	$<0.05^{*}$	0.232

Statistical test used: Pearson correlation test. $p<0.001^{***}$indicates very highly significant difference, $p<0.01^{**}$indicates highly significant difference, $p<0.05^{*}$indicates significant difference, p>0.05 indicates non significant difference between BMI and indexed CAM of total, total male and total female samples.
Abbreviations: BMI-Body mass index, CAM- Coronary artery measurements,Indp.Variable- Independent variable, NSP- Normal Sample population,CAS- Coronary artery segments, r- correlation coefficient, T-Total normal samples, M- Male, F- Female, LMCA - Left main coronary artery, LAD (O, P) - Left anterior descending artery (Ostium, Proximal part),DIAG - Diagonal branch of LAD, LCx (O, P) - Left circumflex coronary artery (Ostium, Proximal part),OM - Obtuse Marginal branch of LCx, RCA (O, P) - Right coronary artery (Ostium, Proximal part), RAM – Ramus branch of coronary artery.

Table 2: Correlation of indexed CAM of normal samples with categorised BMI values (n=933).

BMI Cs	Correlation analysis	CAS included for correlation analysis									
		LMCA	LAD-o	LAD-p	DIAG	LCX-o	LCX-p	OM	RCA- o	RCA- p	RAM
U.W	r	0.078	0.121	0.094	-0.049	-0.014	-0.021	0.104	0.057	0.083	0.643
	p-value	0.662	0.489	0.597	0.780	0.937	0.903	0.554	0.746	0.635	0.242
N	r	-0.045	-0.020	-0.017	0.080	0.013	0.029	0.014	0.073	0.007	-0.374
	p-value	0.552	0.791	0.819	0.291	0.864	0.693	0.849	0.332	0.927	0.153
OW	r	-0.143	-0.137	-0.086	-0.060	-0.142	-0.089	-0.91	-0.068	-0.047	-0.230
	p-value	**$<0.01^{**}$**	**$<0.01^{**}$**	0.081	0.224	**$<0.01^{**}$**	0.069	0.065	0.171	0.342	0.104
OB	r	-0.034	-0.021	-0.041	-0.080	-0.089	-0.015	0.039	-0.118	-0.062	-0.150
	p-value	0.616	0.759	0.550	0.246	0.193	0.829	0.573	0.084	0.362	0.439

The normal saples were categorized based on'WHO Expert Consultation; Appropriate-BMI values of Asian populations for BMI', 2004 [41]
Statistical test used: Pearson correlation test. $p<0.001^{***}$indicates very highly significant difference, $p<0.01^{**}$indicates highly significant difference, $p<0.05^{*}$indicates significant difference, p>0.05 indicates non significant difference between categorised normal BMI samples and indexed CAM of total samples.
Abbreviations: CAM- Coronary artery measurements,BMI Cs-Body mass index categories, CAS- Coronary artery segments,U.W- under weight, N-Normal, OW- over weight, OB- Obese, r- correlation coefficient, LMCA - Left main coronary artery, LAD (O, P) - Left anterior descending artery (Ostium, Proximal part), DIAG - Diagonal branch of LAD, LCx (O, P) - Left circumflex coronary artery (Ostium, Proximal part),OM - Obtuse Marginal branch of LCx, RCA (O, P) - Right coronary artery (Ostium, Proximal part), RAM – Ramus branch of coronary artery.

as in gender wise categorised samples. Hence, the correlation analyses of non-indexed CAM of normal samples with categorised BMI values for for Asian populations [3], were not done.

DISCUSSION

The association of BMI and comorbidities are perhaps not consistent within populations over time. In the present study, it was observed that when BMI increases there wasa relative decrease in coronary artery diameter. The main ethnic groups of India comprise of three categories, i.e., Indo-Aryan (North Indian), Mongoloid (North East Indian), and Dravidian (South Indian) populations. The series of body composition analyses using a standard format confirmed that there are obvious differences in the relation between BMI, BSA and the percentage of body fat across ethnic groups [13]. Ethnicity, an overlooked perspective of the obesity epidemic could be related to different socioeconomic trajectories, thus representing one of the axes of social adversity associated with the weight change [14].

Present study did not have any statistically significant correlations among total samples of non-indexed CAM with BMI cut-off levels suggested for Asian populations. Leung *et al.* (1991), [15], also reported no significant correlation between coronary artery dimensions with the anthropometric measurements or with BSA. Similar results were observed by Samet *et al.* (2015), with no significant correlation between cross-sectional area of the coronary artery and BMI of the patients in their studies. But cross-sectional area of the coronary artery and height of the patients had a weak positive correlation [16]. Even though these studies have not mentioned whether they used indexed or non-indexed data, it was assumed as non-indexed data. However, for indexed CAM an overall significant negative correlation was

Table 3: Correlation of BMI with non-indexed CAM in normal samples (n=933).

Indp. Variable	Correlation		CAS included for correlation analysis									
	analysis	NSP	LMCA	LAD-o	LAD- p	DIAG	LCX- o	LCX- p	OM	RCA- o	RCA- p	RAM
BMI	r	T	0.013	0.001	0.001	-0.010	-0.055	0.012	0.022	-0.050	0.006	0.047
	p-value		0.687	0.972	0.979	0.761	0.100	0.722	0.516	0.131	0.849	0.643
	r	M	-0.004	-0.005	0.018	-0.014	-0.094*	-0.013	-0.035	0.009	0.055	0.026
	p-value		0.936	0.906	0.685	0.759	<0.05*	0.763	0.430	0.846	0.220	0.841
	r	F	0.035	0.014	-0.005	0.001	-0.019	0.041	0.076	-0.197**	-0.095	0.104
	p-value		0.484	0.776	0.923	0.981	0.703	0.415	0.133	<0.001***	0.059	0.519

Statistical test used: Pearson correlation test. p<0.001***indicates very highly significant difference, p<0.01**indicates highly significant difference, p<0.05*indicates significant difference, p>0.05 indicates non significant difference between BMI and non-indexed CAM of total, total male and total female samples.

Abbreviations: BMI-Body mass index, CAM- Coronary artery measurements, Indp.Variable- Independent variable, CAS- Coronary artery segments, NSP- Normal Sample population, r- correlation coefficient, T-Total normal samples, M- Male, F- Female, LMCA - Left main coronary artery, LAD (O, P) - Left anterior descending artery (Ostium, Proximal part),DIAG - Diagonal branch of LAD, LCx (O, P) - Left circumflex coronary artery (Ostium, Proximal part),OM - Obtuse Marginal branch of LCx, RCA (O, P) - Right coronary artery (Ostium, Proximal part), RAM – Ramus branch of coronary artery.

found with BMI for both total and male samples. Other studies utilizing indexed CAM data have not found any such correlation in total samples between BMI and CAM. But similar to the present study Yasmin *et al*. (2013), reported a gender specific and age dependant significant correlation between RCA diameter and BMI of the male samples [17]. This is plausible because higher the BMI more will be fat deposit and smaller will be the coronary dimensions. Smaller coronaries would theoretically require a lower atheroma burden to develop stenosis thereby leading to premature CAD. The risk of cardio metabolic multimorbidity increases as BMI increases. Risk severity was observed more in obese and moderately to severe overweight people compared with individuals with a healthy BMI [18]. The same was observed in the present study

Asian populations have higher cardiovascular risk factors than western populations at any given levels of BMI. Zeina *et al*. (2007), [19] also reported significant correlation between LMCA cross-sectional area of male samples with height, weight, and BSA [20]. This indicates that cardiologists should pay more attention to BMI among male patients, as it seems to have effect on coronary artery morphology and this in turn will have effect on patient outcome. Yet, there are some who believe that BMI alone is not such an important factor for CAM. George *et al*. (2014), has propounded that environmental factors are the major predictors for obesity and degree or distribution of body fat cannot be represented accurately by BMI [21]. Considering the epidemic of obesity induced diseases it is understandable that there could be multiple factors affecting its occurrence like social, economic, environmental and genetic.

CONCLUSIONS

The present study concludes that with increase in BMI, there was a relative decrease in coronary artery diameter. The risk of CAD and associated multimorbidity is directly proportional to BMI. Risk severity was observed more in obese (higher high risk) and moderately to severe overweight (increased risk) people compared with individuals with a healthy BMI.

HIGHLIGHTS OF THE STUDY

Present study reports the largest multi-centric data of coronary artery dimensions among Indian population. The study included patients with different clinical presentations from 4 states of south India, thereby having a diverse representation of the south Indian population.

LIMITATIONS OF THE STUDY

We could correlate the diet habits, life style, physical activity and age, adjusted data with BMI to coronary artery measurements. This would have enhanced the study results.

CONFLICT OF INTEREST

All authors have none to declare. We declare there is no conflict of interest and no financial supports or grants were received for conduction of the study.

AUTHOR CONTRIBUTIONS

All authors hereby declare that their contribution was equal towards the formation of the manuscript.

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