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Original Article / Özgün Makale

Normal coronary diameters in Turkish population

Türk toplumunda normal koroner çapları

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ABSTRACT

Background: This study aims to define normal coronary artery diameters of males and females in a sample of Turkish population, compared to Asian-Indian and Western Caucasian populations.

Methods: Angiographic and demographic data of a total of 324 patients (147 males, 177 females; mean age 55.3±10.1 years; range, 32 to 82 years) who underwent elective coronary angiography with angiographically normal coronary arteries between July 2017 and March 2019 were analyzed retrospectively. Proximal diameters of major epicardial coronary arteries were measured using the Axiom Artis software according to edge detection method. All the measurements were adjusted to the body surface area. Unadjusted and adjusted values were compared between genders and with the Asian-Indian and Caucasian population samples.

Results: The mean diameters of unadjusted/adjusted left main coronary artery, proximal left anterior descending artery, proximal left circumflex artery, and proximal right coronary artery were 4.5±0.6 mm/2.4±0.4 mm/m^2, 3.7±0.5 mm/1.9±0.3 mm/m^2, 3.3±0.6 mm/1.7±0.3 mm/m^2, and 3.4±0.6 mm/1.8±0.4 mm/m^2, respectively. Adjusted left main coronary artery and proximal left circumflex artery were narrower, and unadjusted proximal left anterior descending artery and unadjusted/adjusted proximal right coronary artery were larger in men, compared to women in the Turkish population. Turkish population had similar body surface area and unadjusted/adjusted coronary diameters with Caucasians, whereas adjusted proximal left anterior descending artery was larger in the Turkish population than in Asian-Indians.

Conclusion: Our study findings on the Turkish population contradict the traditional belief that women have narrower coronary arteries then men. Furthermore, the Turkish population have comparable adjusted/unadjusted coronary diameters with the Western Caucasians, but larger adjusted/unadjusted proximal left anterior descending artery, compared to Asian-Indians. We believe that our findings may contribute to the global data pool of normal coronary diameters and can be utilized in future studies as a database.

Keywords: Epidemiology, normal coronary diameter, quantitative coronary angiography Turkish population.

ÖZ

Amaç: Bu çalışmada Asya-Hindistan ve Batılı beyaz ırk toplumlarına kıyasla, Türk toplum örnekleminde erkeklerin ve kadınların normal koroner arter çapları tanımlandı.

Çalışma planı: Temmuz 2017 ile Mart 2019 tarihleri arasında elektif koroner anjiyografi yapılan ve anjiyografide koroner arterleri normal olan toplam 324 hastanın (147 erkek, 177 kadın; ort. yaş 55.3±10.1 yıl; dağılım, 32-82 yıl) anjiyografik ve demografik verileri retrospektif olarak incelendi. Majör epikardiyal koroner arterlerin proksimal çapları, Axiom Artis yazılımı kullanılarak kenar saptama yöntemi ile ölçüldü. Tüm ölçümler vücut yüzey alanına göre endekslendi. Endekslenmiş ve endekslenmemiş veriler cinsiyetler arasında ve Asya-Hindistan ve beyaz ırk toplum örneklemleri ile karşılaştırıldı.

Bulgular: Endekslenmemiş/endekslenmiş sol ana koroner arter, prosimal sol ön inen arter, proksimal sol sirkumfleks arter ve proksimal sağ koroner arterin ortalama çapları sırasıyla 4.5±0.6 mm/2.4±0.4 mm/m^2, 3.7±0.5 mm/1.9±0.3 mm/m^2, 3.3±0.6 mm/1.7±0.3 mm/m^2 ve 3.4±0.6 mm/1.8±0.4 mm/m^2 idi. Kadınlara kıyasla erkeklerde endekslenmiş sol ana koroner arter ve proksimal sol sirkumfleks arter daha dar ve endekslenmemiş proksimal sol ön inen arter ve endekslenmemiş/endekslenmiş proksimal sağ koroner arter daha geniş bulundu. Türk toplumu, beyaz ırk toplumuna benzer vücut yüzey alanına ve endekslenmemiş/endekslenmiş koroner çapa sahip iken, endekslenmiş proksimal sol ön inen arter Asya-Hindistan toplumuna kıyasla Türk toplumunda daha geniş idi.

Sonuç: Türk toplumunda saptadığımız bulgular, geleneksel inanış olan kadınların erkeklerden daha dar koroner arter çaplarına sahip olduğu inanışıyla çelişmektedir. Ayrıca, Türk toplumu Batılı beyaz ırk toplumuna benzer koroner arter çaplarına sahip iken, Asya-Hindistan toplumuna kıyasla endekslenmiş/endekslenmemiş proksimal sol ön inen arter çapı daha geniştir. Bu bulguların normal koroner çapları konusunda küresel veri havuzuna katkı sağlayabileceği ve gelecek çalışmalarda veri tabanı olarak kullanılabileceği kanısındayız.

Anahtar sözcükler: Epidemiyoloji, normal koroner çap, kantitatif koroner anjiyografi, Türk toplumu.

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Cardiovascular diseases account for around one out of every three deaths worldwide.[1] Similarly, ischemic cardiac disease is the leading cause of mortality in Turkey, and has been suggested to place a far greater financial burden over the next 20 years than today.[2] Therefore, strenuous efforts are exercised to be able to better prevent and manage coronary diseases.[3,4] Accordingly, acquiring a true notion of coronary anatomy is of paramount importance, including normal diameters of coronary arteries.

In healthy individuals, coronary dimensions are subjected to changes on the basis of various conditions such as gender differences, aging, racial/ethnicity factors, body surface area (BSA), body weight, vasomotor tone, and left ventricular mass.[5,6] Furthermore, formation of a reliable database for normal coronary diameters and the normal diameters adjusted for age, gender, BSA, and racial factors may prove useful in the attempts to improve interventional cardiac procedures and coronary artery bypass grafting. The number of studies evaluating quantitative angiographic normal dimensions of coronary arteries and comparing these dimensions among genders and different racial/ethnic groups is scarce and relatively old. In addition, the number of the individuals included in these studies is low.

Previous studies have demonstrated that the Caucasian have larger coronary artery diameters compared to the Asian-Indians owing to relatively their smaller BSA; however, while adjusting the normal coronary dimensions for BSA, no significant difference has been reported. Similarly, there are conflicting results about the gender effect on both unadjusted and BSA-adjusted coronary artery diameters.

In the literature, there is only one study regarding the angiographic normal diameters of coronary arteries in the Turkish population. However, this study provided only the unadjusted coronary diameters in the absence of such demographic features as BSA and body mass index (BMI) in a small patient population (n=77). Therefore, in the current study, we aimed to evaluate normal coronary artery diameters more comprehensively in a larger Turkish population compared to the Asian-Indians and the Caucasians.

PATIENTS AND METHODS

We retrospectively analyzed the hospital records of a total of 324 patients (147 males, 177 females; mean age 55.3±10.1 years; range, 32 to 82 years) who underwent elective coronary angiography in our institution due to suspicion of coronary artery disease between July 2017 and March 2019 and in whom coronary angiography documented normal coronary arteries without any intra-luminal irregularity. *Exclusion criteria were as follows:* moderate-to-severe stenotic or regurgitant valvular heart disease, history of acute coronary syndrome, evidence of localized or widespread coronary atherosclerosis, dilated or hypertrophic cardiopathy, severe renal failure, chronic inflammatory diseases, evidence of coronary vasospasm during the procedure, and administration of nitroglycerine before image acquisition. A written informed consent was obtained from each patient. The study protocol was approved by the institutional Ethics Committee of Kırşehir Ahi Evran University Medical Faculty. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Calculation of proximal coronary artery diameters

Coronary angiographies were performed via Siemens Artis Zee (Siemens Medical Solution, Erlangen, Germany) through the transfemoral route using 5F/6F Amplatz or Judkins right and left coronary diagnostic catheters. Standard projections recorded at 15 frames/sec were obtained from each patient. Proximal diameters of the main epicardial coronary arteries were measured quantitatively by an experienced cardiologist using automated software analysis (Axiom, Siemens Medical Solution, Erlangen, Germany). Calibration for the coronary diameter was performed with reference to the catheter diameter. This quantitative angiography with the help of edge detection method is compatible with the previous studies.[7-12] Location of the pertinent proximal coronary diameters for the measurement were as follows: mid-part of the left main coronary artery (LMCA); mid-part of the proximal left anterior descending artery (pLAD) between its origin and the first diagonal branch; mid-part of the proximal left circumflex artery (pLCx) between its origin and the first obtuse marginalis branch; and 1.5 to 2 mm of the proximal right coronary artery (pRCA) after it was given off from the aorta.[8,10] Right anterior oblique projections were used for the diameter calculation of LMCA, pLAD, pLCx, while left anterior oblique projection was used for pRCA.[9-12] The LMCA length was also measured from its origin, until where it bifurcates into the left anterior descending (LAD) and left circumflex (LCx) arteries using right anterior oblique projections. Furthermore, we also adjusted all the diameter measures and LMCA lengths for BSA of each relevant patient. In this regard, the Mosteller's formula[13] was implemented in the calculation of BSA: BSA (m^2) = square root of ([Height(cm) × Weight(kg)]/3600). The BMI was calculated as weight in kilograms divided by the

square of height in meters (kg/m^2). The average values of both unadjusted and adjusted proximal coronary diameters were compared with former two respective studies consisting of Asian-Indian population[7] and Western Caucasian[9] population.

Statistical analysis

Statistical analysis was performed using the IBM SPSS for Windows version 21.0 software (IBM Corp., Armonk, NY, USA). Quantitative data were assessed for normality using the Kolmogorov-Smirnov test. Continuous variables were expressed in mean ± standard deviation (SD), while categorical variables were expressed in number and frequency. Proximal coronary diameters were compared on the basis of gender within the study population using independent sample t-test. The comparison between the Turkish versus Asian-Indian populations and Turkish versus Western Caucasian populations was made using the Student t-test. A *p* value of <0.05 was considered statistically significant.

RESULTS

Demographic and clinical characteristics of the patients are presented in Table 1. The mean BMI and BSA were 29.0±5.3 kg/m^2 and 1.9±0.2 m^2, respectively. Cardiovascular risk factors, in order of frequency, were hypertension (25.6%), smoking (22.8%), hyperlipidemia (12.9%), family history for premature coronary artery disease (11%), and diabetes mellitus (7.7%). Of 324 patients, 254 (78.3%) had right coronary dominance.

Table 2 shows the total and gender-specific unadjusted and adjusted proximal coronary diameters.

Table 1. Baseline demographic and clinical characteristics of the study population

	n	%	Mean±SD
Age, year			55.3±10.1
Gender			
Female	177	54.6	
Height (cm)			165.9±8.7
Weight (kg)			79.6±14.8
BMI (kg/m^2)			29.0±5.3
BSA (m^2)			1.9±0.2
Family history of CAD	32	11	
Hypertension	83	25.6	
Diabetes mellitus	25	7.7	
Smoking	74	22.8	
Hyperlipidemia	42	12.9	
Coronary artery dominance			
Right dominance	254	78.3	
Left dominance	58	17.9	
Co-dominance	12	3.7	

SD: Standard deviation; BMI: Body mass index; BSA: Body surface area; CAD: Coronary artery disease.

Accordingly, the LMCA and pLCx diameters were similar between both genders (p>0.05), whereas pLAD (p=0.003) and pRCA (p=0.001) were significantly larger in men compared to women (Figure 1). However, when adjusted for BSA, the diameter of adjusted LMCA (p=0.005) and adjusted pLCx (p<0.001) were larger in women, while that of adjusted pRCA (p=0.001) was larger in men, compared to the other gender. There was no significant difference in the adjusted pLAD diameter between two genders (p>0.05). The mean

Table 2. Comparison of crude and BSA-adjusted proximal coronary artery diameters and length of left main coronary artery between genders

	Total population (n=324)	Female gender (n=177)	Male gender (n=147)	
	Mean±SD	Mean±SD	Mean±SD	*p**
LMCA diameter (mm)	4.5±0.6	4.4±0.6	4.6±0.6	0.520
Adjusted-LMCA diameter (mm/m^2)	2.4±0.4	2.4±0.4	2.4±0.3	0.005
LAD diameter (mm)	3.7±0.5	3.6±0.4	3.8±0.5	0.003
Adjusted-LAD diameter (mm/m^2)	1.9± 0.3	1.9±0.3	1.9±0.3	0.742
LCx diameter (mm)	3.3±0.6	3.3±0.6	3.3±0.6	0.993
Adjusted-LCx diameter (mm/m^2)	1.7±0.3	1.8±0.4	1.7±0.3	<0.001
RCA diameter (mm)	3.4±0.6	3.3±0.7	3.6±0.5	0.001
Adjusted-RCA diameter (mm/m^2)	1.8±0.4	1.8±0.4	1.8±0.3	0.001
Length of LMCA (mm)	11.3±3.2	11.2±3.0	11.5±3.4	0.344
Adjusted-length of LMCA (mm/m^2)	6.0±2.0	6.0±1.9	6.0±2.1	0.969

BSA: Body surface area; SD: Standard deviation; LMCA: Left main coronary artery; LAD: Left anterior descending artery; LCx: Left circumflex artery; RCA: Right coronary artery; * Females vs. males.

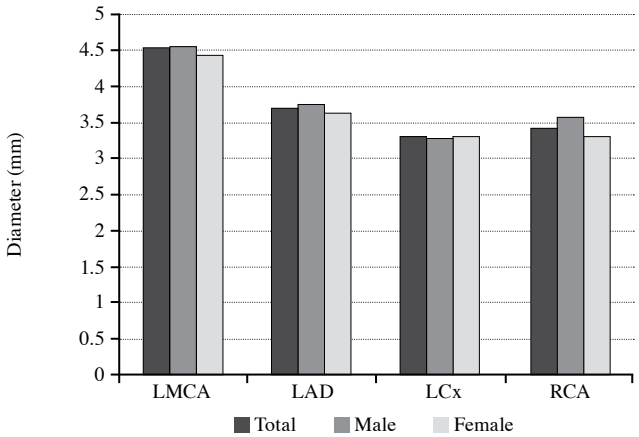

Figure 1. Graphical depiction of mean unadjusted proximal coronary dimensions on the basis of gender.

LMCA: Left main coronary artery; LAD: Left anterior descending artery; LCx: Left circumflex artery; RCA: Right coronary artery

unadjusted length of LMCA was 11.3±3.2 mm and adjusted length of LMCA was (6.0±2.0 mm/m^2) in the overall study population. In addition, there was no statistically significant difference between the females and males in terms of the unadjusted/adjusted length of LMCA (11.2±3.0 mm vs. 11.5±3.4 mm for unadjusted values, p=0.344; and, 6.0±1.9 mm/m^2 vs. 6.0±2.1 mm for adjusted values, p=969; respectively).

The unadjusted/adjusted proximal coronary diameters of the Asian-Indian Population (n=229, female 47.1%, mean age: 51.7±9.4 years) and the Western Caucasian population (n=77, female 49.3%, mean age: 53.3±10.3 years) are shown in Table 3. The BSA was similar between our population and the Western Caucasians (p>0.05), whereas the BSA of Asian-Indian population was significantly lower than our study cohort (p<0.05). There was no significant difference in the unadjusted/adjusted proximal coronary diameters between our population and the Western Caucasians (p>0.05). On the other hand, unadjusted LMCA, pLAD, pLCx, and pRCA diameters were significantly larger in our population, compared to the Asian-Indians (p<0.05). Although our population's adjusted LMCA, pLCx, and pRCA diameters were similar to those of Asian-Indians (p>0.05), adjusted pLAD remained to be larger in our population, compared to the Asian-Indian population (p<0.05).

DISCUSSION

The main findings of the present study can be summarized as follows: *(i)* Turkish population had a comparable BSA and proximal coronary luminal diameter with Western Caucasians, which also holds true even when these diameters were adjusted for BSA; *(ii)* The BSA and proximal coronary diameters of the Turkish population were larger than those of Asian-Indian population. Although the adjusted diameters for BSA in the Turkish population were similar to those of Asian-Indians, adjusted pLAD was larger compared to that of Asian-Indians. In this regard, our study is the first comprehensive study with a larger

Table 3. Comparison of Turkish population data with Asian-Indian and Caucasian population data from different studies

	Present Study (Turkish population (n=324)		Asian-Indian population[5] (n=229)			Caucasian population[7] (n=77)		
	n	Mean±SD	n	Mean±SD	*p**	n	Mean±SD	*p***
Gender								
Male	147		121			39		
Female	177		108			38		
BSA (m^2)		1.9±0.2		1.8±0.1	<0.05		1.9±0.2	>0.05
LMCA (mm)		4.5±0.6		4.1±0.4	<0.05		4.4±0.9	>0.05
Adjusted-LMCA (mm/m^2)		2.4±0.4		2.3±0.3	>0.05		2.4±0.5	>0.05
LAD (mm)		3.7±0.5		3.3±0.2	<0.05		3.5±0.7	>0.05
Adjusted-LAD (mm/m^2)		1.9± 0.3		1.9±0.2	<0.05		1.9±0.4	>0.05
LCx (mm)		3.3±0.6		3.0±0.4	<0.05		3.2±0.6	>0.05
Adjusted-LCX (mm/m^2)		1.7±0.3		1.7±0.2	>0.05		1.7±0.3	>0.05
RCA (mm)		3.4±0.6		3.2±0.4	<0.05		3.4±0.7	>0.05
Adjusted-RCA (mm/m^2)		1.8±0.4		1.8±0.2	>0.05		1.8±0.4	>0.05

SD: Standard deviation; BSA: Body surface area; LMCA: Left main coronary artery; LAD: Left anterior descending artery; LCx: Left circumflex artery; RCA: Right coronary artery; * Turkish population vs. Asian-Indian population; ** Turkish population vs. Caucasian population.

study population and more inclusive demographics ever conducted on normal coronary dimensions of the Turkish population.

Gender and BSA have been suggested to influence normal coronary diameters, although the influence of BSA has been reported to be much higher than the former. Traditional premise is in favor of the hypothesis that women have narrower coronary arteries compared to men. However, sole gender influence on normal coronary dimensions has yet to be completely unraveled. In an intracoronary ultrasound study, Kim et al.[14] showed that LMCA luminal cross-sectional area was independently associated more with the BSA than with male gender according to linear regression model; however, they did not interrogate ethnicity/racial factor in their study. In another study, Dickerson et al.[15] measured cross-sectional areas of proximal epicardial coronary arteries using cardiac tomography and concluded that gender's influence on the unadjusted coronary dimensions was only on the pLAD and pRCA with the men being characterized with larger pLAD and pRCA compared to women as evidenced by linear regression analysis. Also, the authors added that pLCx along with the distal dimensions of the LAD, RCA, and LCx, were similar between both genders, and that BSA was not independently associated with the proximal coronary dimensions. Similar to the findings of Dickerson et al.,[15] our study also documented larger unadjusted diameters of pLAD and pRCA in men compared to women. Furthermore, not only unadjusted pLCx diameter, but also the LMCA diameter was similar between both gender in the Turkish population in our study. Interestingly, while adjusted LMCA and adjusted pLCx were larger in women than in men, adjusted pLAD was similar between both genders and adjusted pRCA was larger in men than in women in the Turkish population. Our findings, thus, oppose the traditional premise which describes women with smaller coronary arteries than men. In a smaller study (n=77) conducted by Turamanlar et al.[8] on the Turkish population, proximal coronary diameters were measured via quantitative coronary angiography and no significant difference was observed between two genders in terms of the proximal coronary dimensions, except for unadjusted pLAD which was found to be larger in men. However, beside relatively smaller size compared to ours, this study did not include and compare the adjusted coronary diameters to BSA in its methodology. Therefore, to the best of our knowledge, our study seems to be the only study with a larger Turkish population where both of adjusted and unadjusted proximal coronary diameters were compared between genders and other ethnic/racial backgrounds. Ultrasonographic and tomographic diameter/dimension measurement may be regarded as more accurate methodologies; however, previous reports have validated the accuracy of anticipation of coronary dimensions using quantitative coronary angiography.[16,17]

As for racial determinants of normal coronary dimensions, previous studies indicated that Asian and Indian populations were characterized with narrower unadjusted proximal coronary diameters, compared to Caucasians.[7,9,11,18] Lip et al.[9] compared unadjusted and adjusted coronary diameters between Indo-Asian and Caucasians settled in the United Kingdom and found that unadjusted LMCA, pLAD, pLCx, and pRCA were larger in Caucasians than the Indo-Asians. However, the same diameters were similar between these two ethnic-racial backgrounds when adjusted for BSA due to smaller BSA of the Indo-Asians than that of the Caucasians. Similarly, Raut et al.[7] reported comparable proximal coronary diameters in Asian-Indians compared to the Western Caucasians when adjusted for BSA. To compare the adjusted and unadjusted proximal coronary diameters of the Turkish population in our study, we utilized the Caucasians settled in the United Kingdom from the study of Lip et al.[9] and the Asian-Indians from the study of Raut et al.[7] In our study, we observed that BSA and both adjusted and unadjusted pLMCA, pLAD, pLCx, and pRCA were similar between the Turkish and Western Caucasian populations, and that the same unadjusted proximal diameters were significantly narrower in Asian-Indians compared to the Turkish population. On the other hand, whereas adjusted LMCA, LCx and RCA turned out to be similar between the Turkish and Asian-Indians, pLAD still perpetuated its statistically significance, even when adjusted for BSA. This finding seems to be unique, considering the results of the aforementioned studies.

There is a number of limitations to the present study. Although this is a larger-scale study compared to the aforementioned studies, our population is confined to a relatively small city in the middle of Anatolia and, hence, cannot reflect the whole Turkish population. In addition, the quantitative measurement method used in our study measures the sole luminal diameter rather than the ultimate vessel diameter itself, which might have affected a straightforward measurement of the true luminal diameter, if slight but diffuse atherosclerosis existed. Preferentially, we did not obtain a pooled data from multiple studies regarding the coronary dimensions of various ethnic/racial populations for the comparison. Rather, we relied solely on the comparison

of the ethnic groups from single Caucasian and Asian-Indian studies.

In conclusion, our study findings on the Turkish population contradict the traditional belief that women have narrower coronary arteries then men suggesting that the adjusted left main coronary artery and proximal left circumflex artery diameters are smaller and unadjusted left anterior descending artery and unadjusted/adjusted right coronary artery are larger in Turkish men than Turkish women. Furthermore, the Turkish population have comparable adjusted/unadjusted coronary diameters with the Western Caucasians, but larger adjusted/unadjusted proximal left anterior descending artery, compared to Asian-Indians. We conjecture that these findings may contribute to global data pool in the scope of determinants of normal coronary dimensions and can be also utilized in future advents in interventional cardiac procedures.

Declaration of conflicting interests

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