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Research Article

Evaluation of the Correlations of SYNTAX scores, Anthropometric Measurements and Epicardial Fat Tissue in Predicting the Risk of Coronary Artery Disease

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Abstract

Aim: To investigate the strength of correlations between some anthropometric parameters, SYNTAX scores and epicardial adipose tissue (EFT) in coronary artery disease (CAD). Also to determine for the first time that the upper half of the chest circumference (CCuH) and neck circumference (NC)/neck length (NL) ratio may be an indicator for predicting cardiovascular risk

Material and Methods: This study included 370 individuals (198 males and 172 females), who were either diagnosed with CAD (n=300) or who were the control group participants (n=70). The EFT was measured and calculated SYNTAX score. Anthropometric measurements included height, weight, NL, NC, Waist circumference (WC), CCuH, Hip circumference (HC), and sagittal abdominal diameter (SAD), Body Mass Index (BMI), Waist circumference/Hip circumference ratio (WHR), and NC/NL ratio. The study was approved by the Niğde Ömer Halisdemir University Non-Interventional Clinical Research Ethics Committee (Protocol number: 2019/29).

Results: The statistical differences in the NL, CCuH, HC, and SAD were observed to be non-significant between the CAD patients and the control group. The NC (367.06±1.99, 37.49±2.64, p=0.04), NC/NL ratio (2.44±0.16, 2.50±0.21, p=0.02), WC (104.69±8.27, 107.55±10.77, p=0.04), Left Ventricular Ejection Fraction (LVEF) (62)-(51) (p<0.001), and EFT (3.06±0.33)-(3.41±0.80) were statistically significantly different between the control group and the CAD group (p<0.001). Elevated SYNTAX scores (r=0.15, p=0.01) and increased EFT (r=0.21, p<0.001) were more common in male patients.

Conclusion: The SYNTAX score was determined to be correlated with the NC, NC/NL ratio, CCuH, WC, HC, WHR, SAD, and EFT and it was found that these parameters increased significantly with increasing SYNTAX scores. These results show that, in addition to the SYNTAX score, anthropometric measurements and EFT quantity can be used for determining the severity of CAD.

Keywords: Anthropometric measurement, coronary artery disease, epicardial fat tissue, syntax score

INTRODUCTION

Changes in eating habits (obesity), smoking, and increased urbanization and the resulting sedentary lifestyle in today's modern societies have caused an increase in cardiovascular system diseases (1-3). Cardiovascular diseases (CVDs) are the leading disorders with the highest mortality and morbidity globally (4). CVDs constitute the main cause of mortality in more than four million deaths every year in Europe. CVDs account for about half (47%) of all these deaths (52% of deaths in women and 42% of deaths in men). The globally high prevalence and the high number of cardiovascular diseases have led to the search for new methods to be used in the diagnosis of the disease (5).

Coronary angiography is an important imaging technique for visualizing coronary vessels and determining the severity of coronary artery diseases. Several scoring methods have been developed by utilizing angiographic images. SYNTAX (SYNergy between PCI with TAXUS and Cardiac Surgery) is a scoring method that can measure the degree of atherosclerosis in the entire coronary artery tree and is calculated separately for each lesion (5,6). This scoring method is used for determining the anatomical features of the coronary vessels, the severity

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of the disease, and the complexity of the event by using angiography images. The SYNTAX score is calculated by answering 12 basic questions of a computer program and allows for the prediction of potential untoward conditions (cardiac and cerebrovascular), which may develop in patients undergoing coronary balloon angiography and stent placement (7-9). This scoring system is globally recommended to determine the revascularization strategy and predict complications in individuals with the disease in the left main coronary artery and/or 3 coronary arteries (5,10).

Obesity is a high risk factor for cardiovascular diseases. Anthropometric measurements are used to predict this risk, individuals and diseases below the risk limits (11). Anthropometric measurements are a set of quantitative measurements to understand the muscle, bone, and adipose tissue composition of the body. To identify the risk of diseases such as diabetes mellitus, cardiovascular diseases, and hypertension; several parameters are measured usually including the weight, height, the circumference of some body parts (waist, hip and limbs), BMI and the waist/hip ratio (12,13). Compared to biochemical tests and imaging techniques; anthropometric measurements are more advantageous owing to the ease of measurement and application, low costs, and easy use in population studies (14).

Accumulating between the visceral pericardium and the myocardium, the epicardial adipose tissue (EFT) is a component of adipose tissue found around the muscles or internal organs (15,16). Studies have found a relationship between the quantity of EFT with the presence and severity of coronary heart diseases (16).

The aim of this study is to investigate the strength of the relationship between some anthropometric parameters, SYNTAX score and EFT in individuals with coronary artery disease. In addition, we sought for the first time to determine whether upper half of the chest circumference (CCuH) and neck circumference/neck length (NC/NL ratio) could be indicators of cardiovascular risk.

MATERIAL AND METHOD

Study Design and Participants

The study included 370 individuals (198 males, 172 females) in the age range from 36 to 86 years, consisting of control participants (n=70) and patients (n=300) diagnosed with coronary artery disease, who applied to the cardiology department of Niğde Ömer Halisdemir University Training and Research Hospital in the period between November 2019 and May 2020. The case group (n=300, Males 55%) in the study was composed of patients; who had at least 50% occlusion of the coronary artery lumen and who underwent angiography, while the control group (n=70, Males 47%) was composed of individuals with normal coronary arteries detected by angiography. The demographic information of the patients was examined. The study was approved by the Niğde Ömer Halisdemir University Non-Interventional Clinical Research Ethics Committee (Protocol number: 2019/29).

Echocardiographic Evaluation

Echocardiography (echo) was performed only by a cardiologist using a 3.5 MHz transducer while the patients were lying in the left lateral decubitus position. EFT was measured by echo before or after angiography (Figure 1).

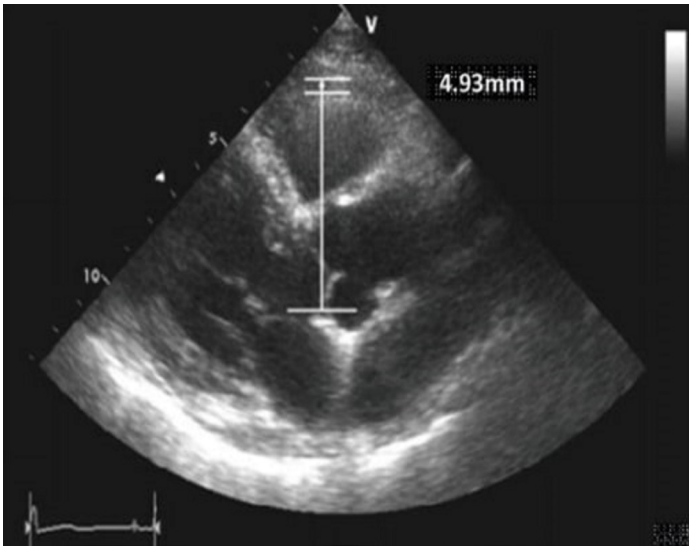

Figure 1. Epicardial fat tissue

EFT was measured in the right ventricular free wall using the long and short axis of the parasternal view. The mean of three beats was calculated and the obtained values were recorded. Measurements were repeated three times and mean values were calculated. Echocardiographic measurements were made in accordance with the standards set by the American Society of Echocardiography (17). Simpson's method was used to calculate the LVEF (18).

Evaluation of the SYNTAX Score

The angiographic images of the patients were evaluated by at least two experienced cardiologists and cardiovascular surgeons. When the same patient was assigned different SYNTAX scores by the experts, these scores were re-evaluated and the SYNTAX score was calculated in a common session by the participation of both parties. The SYNTAX score was calculated on the computer by answering 12 basic questions from the website (www.syntaxscore.com) taking into account the vessels with a diameter of at least 1.5 mm having more than 50% occlusion of the vessel lumen. The 300 CAD patients, whose SYNTAX scores (SS) were calculated, were divided into three groups as the low (A) (SS≤17), intermediate (B) (SS=18-28), and high (C) (SS≥29) score groups.

Anthropometric Evaluation

The anthropometric parameters including the height, weight, BMI, NL, NC, WC, CCuH, HC, and the SAD were measured before or after coronary angiography. By proportioning some of these measurements, the WHR, the NC/NL ratio, and BMI were calculated. A scale for body weight, a measuring tape, and a stadiometer were used for the anthropometric measurements. The points and the

parameters used for the anthropometric measurements are presented in Table 1.

Table 1. Anthropometric parameters and descriptions

Waist Circumference (WC)	Measured on the imaginary horizontal line extending circumferentially around the waist on the middle of the distance between the edge of the lowest rib and the iliac crest;
Hip Circumference (HC)	Measured on the arbitrary horizontal line extending over the two major trochanters of the femur circumferentially, while the patient is standing up with legs held together;
Neck Circumference (NC)	Measured on the arbitrary horizontal line passing just below the laryngeal prominence (Prominentia laryngea) circumferentially around the neck;
Neck Length (NL)	Measured alongside the sternocleidomastoid muscle between the sternoclavicular artery and the mastoid process;
Upper Half-Chest Circumference (CCuH)	Measured along an arbitrary horizontal line around the chest at the level of the uppermost parts of the axilla;
Sagittal abdominal diameter (SAD)	Measured on the midline between the iliac crest and the lowest rib at the level of the umbilicus.
BMI	Kg/m^2

Statistical Analysis

Study data were analyzed using the SPSS package program version 23.0. One-way ANOVA, Chi-square and correlation analysis methods were used in the data analysis of this study. ANOVA was used when the dependent variable was continuous and the independent variable was the group. When both variables were dichotomous, Chi-square was used to evaluate the difference. Correlation analysis was used to evaluate the relationships between variables. Statistical significance was accepted as $p<0.05$.

RESULTS

It was found that 47% of the control group and 55% of the case group were males (Table 2). The age range of the participants in the study was 57.22±11.31 in the case group and 55.74±10.11 in the control group (Table 2). Considering the demographic information of the patients, peripheral artery disease (PAD) was detected in 40 (13%) patients in the case group and in 3 (4%) patients in the control group. The difference between the two groups was statistically significant (p=0.03) (Table 2). The examination of the medical histories of the patients revealed 1 (1%) hyperlipidemia (HL) patient in the control group and 45 (15%) HL patients in the group of CAD patients, whose SYNTAX scores were calculated. There was a statistically significant difference between the two groups (p<0.001) (Table 2). The number of COPD, DM, and HT patients were 10 (14%)-54 (18%), 15 (21%)-87 (29%), and 17 (24%)-102 (24%) for the case and control groups, respectively. As for the smoking status, no statistical differences were observed between the case group and the control group.

It was observed that the statistical differences in the NL, CCuH, HC, and the SAD were non-significant between the CAD patients and the participants in the control group (Table 2). The statistical differences in BMI (p=0.3), WHR (p=0.2), NC/NL ratio (p=0.02), WC (p=0.04), NC, LVEF (p<0.001), and EFT (p<0.001) were significant (Table 2). Table 2 shows that the statistical differences between the CAD patients and the control group were non-significant for the NL and NC but significant for the NC/NL ratio (p=0.02).

Table 2. Evaluation of the case group (A+B+C) and the control group by the study parameters

Parameters	Control group (n=70)	CAD GROUP (n=300)	p
Male, n (%)	33 (%47)	165 (%55)	.24
Age (years)	55.74±10.11	57.22±11.31	.32
Height (cm)	1.67±.08	1.67±.08	.39
Weight (kg)	76.59±13.56	77.17±14.08	.09
BMI (kg/m^2)	26.56±2.53	27.28±3.44	.10
NL(cm)	15.27±1.16	15.08±1.30	.25
NC (cm)	37.06±1.99	37.49±2.64	.20
NC/NL	2.44±.16	2.50±.21	.02
CCuH (cm)	103.03±5.00	104.80±5.80	.07
WC(cm)	104.69±8.27	107.55±10.77	.04
HC (cm)	108.23±5.93	108.88±4.66	.32
WHR	.97±.06	.99±.09	.08
SAD (cm)	25.86±1.80	26.08±1.81	.35
LVEF (%)	62 (60-64)	51(45-58)	.00
EFT (mm)	3.06±.33	3.41±.80	.00
PAD n, (%)	3 (%4)	40 (%13)	.03
COPD n, (%)	10 (%14)	54 (%18)	.46
DM n, (%)	15 (%21)	87 (%29)	.20
HT n, (%)	17 (%24)	102 (%24)	.12
HL n, (%)	1 (%1)	45 (%15)	.00
Smokers, n (%)	28 (%40)	122 (%41)	.91

BMI: Body Mass Index, WC: Waist circumference, HC: Hip circumference, NC: Neck circumference, NL: Neck length, NC/NL: Neck circumference/Neck length ratio, CCuH: Upper half-chest circumference, SAD: Sagittal abdominal diameter, WHR: Waist circumference/Hip circumference ratio, LVEF: Left Ventricular Ejection Fraction, PAD: Peripheral Arterial Disease, COPD: Chronic Obstructive Pulmonary Disease, DM: Diabetes Mellitus, HT: Hypertension HL: Hyperlipidemia

The coronary artery patients were divided into three groups by the SYNTAX scores as low (A), intermediate (B), and high (C) score groups to demonstrate the relationships across them (Table 3). In A, B, and C groups; 69 (48%), 51 (59%), and 46 (66%) individuals were males,

respectively, this was statistically significant between the patients with low and high SYNTAX scores (p=0.02). The mean age of 62.43±13.02 years in the high SYNTAX score group was found to be significantly different compared to the patients in both the low and the intermediate score groups (p<0.001; p<0.001).

Table 3 shows that the statistical differences in BMI, NL, NC, the NC/NL ratio, WC, HC, SAD, PAD, COPD, DM, HT, and the number of smokers were non-significant between the A and B groups. However, the differences in the CCuH, WHR, LVEF, EFT and HL were found to be significant between the groups A and B (p<0.05). The evaluation of the differences in the study parameters between the groups A (low-score group) and C (high-score group) revealed that the statistical differences in the NL, LVEF, COPD, and the smoking status were non-significant but the statistical differences in BMI, NC, NC/NL ratio, CCuH, WC, HC, WHR, SAD, EFT, PAD, DM, HT and HL were significant (p<0.05).

Between the groups B and C, the statistical differences in the NL, NC/NL ratio, SAD, LVEF, and COPD were non-significant but the statistical differences in BMI, NC, CCuH, WC, HC, WHR, EFT, PAD, DM, HT, HL, and the smoking status were significant (p<0.05).

The correlation of the parameters with SYNTAX scores and EFT are presented in Table 4. High SYNTAX scores (r=0.15, p=0.01) and more EFT (r=0.21, p=0.00) were observed in male patients more commonly. The SYNTAX scores were found to increase significantly with advancing age (r=0.28, p=0.00) but no correlations were found between EFT and age.

BMI (r=0.39, p<0.001; r=0.36, p<0.001), NC (r=0.29, p<0.001; r=0.29, p<0.001), CCuH (r=0.34, p<0.001; r=0.48, p<0.001), WC (r=0.40, p<0.001; r=0.42, p<0.001), HC (r=0.25, p<0.001; r=0.18, p<0.001), WHR (r=0.28, p<0.001; r=0.14, p=0.01), and the SAD (r=0.19, p<0.001; r=0.30, p<0.001) were positively correlated with both the SYNTAX scores and EFT (Table 4). The NC/NL ratio (r=0.14, p=0.02) was positively correlated with the SYNTAX scores but not correlated with EFT. The NL (r=0.24, p<0.001) was positively correlated with EFT but not correlated with the SYNTAX scores. The LVEF value was non-significant by the SYNTAX scores but negatively correlated with EFT (r=-0.16, p<0.001). When the correlation between the SYNTAX score and EFT was examined, it has been observed that these two parameters were statistically significant for each other and showed a positive correlation (r=0.59, p<0.001).

Table 3. Evaluation of the low, intermediate, and high syntax scores by the study parameters

Parameters	Low SYNTAX scores (A) n=143	Intermediate SYNTAX scores (B) n=87	High SYNTAX scores (C) n=70	A-B p-value	A-C p-value	B-C p-value
Male, n (%)	69 (%48)	51 (%59)	46 (%66)	.18	.02	.29
Age (years)	55.02±10.42	56.64±9.94	62.43±13.02	.25	.00	.00
Height (cm)	1.68±.08	1.67±.08	1.70±.08	.63	.00	.03
Weight (kg)	73.31±9.46	75.72±14.98	86.84±16.33	.14	.00	.00
BMI (kg/m2)	26.31±2.51	26.87±3.77	29.75±3.53	.17	.00	.00
NL (cm)	15.04±1.27	15.01±1.37	15.23±1.30	.86	.32	.31
NC (cm)	37.03±1.54	37.28±1.95	38.69±4.31	.29	.00	.01
NC/NL	2.47±.16	2.50±.18	2.55±.30	.31	.02	.18
CCuH (cm)	102.86±4.59	104.36±6.13	107.53±6.40	.04	.00	.00
WC (cm)	104.50±7.15	106.83±10.68	114.69±13.56	.07	.00	.00
HC (cm)	108.22±4.58	108.24±4.03	111.04±4.94	.97	.00	.00
WHR	.97±.07	.99±09	1.03±.11	.02	.00	.02
SAD (cm)	25.81±1.93	26.20±1.47	26.50±1.87	.11	.01	.25
LVEF (%)	52 (46-52)	50 (45-51)	50 (42-58)	.04	.08	.85
EFT (mm)	3.05±.36	3.31±48	4.27±1.09	.00	.00	.00
PAD n, (%)	6 (%4)	9 (%10)	25 (%36)	.07	.00	.00
COPD n, (%)	20 (%14)	18 (%21)	16 (%23)	.18	.11	.74
DM n, (%)	31 (%22)	21 (%24)	35 (%50)	.67	.00	.00
HT n, (%)	33 (%23)	28 (%32)	41 (%59)	.13	.00	.00
HL n, (%)	3 (%2)	8 (%9)	34 (%49)	.01	.00	.00
Smokers, n (%)	58 (%40)	43 (%49)	21 (%30)	.19	.13	.01

BMI: Body Mass Index, WC: Waist circumference, HC: Hip circumference, NC: Neck circumference, NL: Neck length, C/NL: Neck circumference/Neck length ratio, CCuH: Upper half-chest circumference, SAD: Sagittal abdominal diameter, WHR: Waist circumference/Hip circumference ratio, LVEF: Left Ventricular Ejection Fraction, PAD: Peripheral Arterial Disease, COPD: Chronic Obstructive Pulmonary Disease, DM: Diabetes Mellitus, HT: Hypertension HL: Hyperlipidemia

Table 4. Correlations of the syntax scores and eft with the study parameters

Parameters	SYNTAX score		Epicardial fat tissue	
	r-value	p-value	r-value	p-value
Male, n (%)	.15	.01	.21	.00
Age (years)	.28	.00	.08	.11
Height (cm)	.20	.00	.33	.00
Weight (kg)	.39	.00	.47	.00
BMI (kg/m2)	.39	.00	.36	.00
NL(cm)	.10	.09	.24	.00
NC (cm)	.29	.00	.29	.00
NC/NL	.14	.02	-.02	.72
CCuH (cm)	.34	.00	.48	.00
WC(cm)	.40	.00	.42	.00
HC (cm)	.25	.00	.18	.00
WHR	.28	.00	.14	.01
SAD (cm)	.19	.00	.30	.00
LVEF (%)	-.05	.36	.-16	.00
EFT (mm)	.59	.00	1	1
SYNTAX score	1	1	.59	.00

BMI: Body Mass Index, WC: Waist circumference, HC: Hip circumference, NC: Neck circumference, NL: Neck length, NC/NL: Neck circumference/Neck length ratio, CCuH: Upper half-chest circumference, WC: waist circumference, HC: hip circumference, WHR: Waist circumference/Hip circumference ratio, SAD: Sagittal abdominal diameter, NC/NL: Neck circumference/Neck length ratio, LVEF: Left Ventricular Ejection Fraction, EFT: Epicardial fat tissue

DISCUSSION

SYNTAX scores are used for selecting the treatment method for revascularization in CAD. The review of the literature has shown that the relationships across the SYNTAX scores, EFT, and anthropometric measurements were determined for the first time in this present study. Our study results have shown that; compared to the patients with low SYNTAX scores, the patients with high SYNTAX scores had significantly higher values of age, weight, height, BMI, NC, NC/NL ratio, CCuH, WC, HC, WHR, SAD, EFT, PAD, DM, HT, and HL. Furthermore, high SYNTAX scores were observed significantly more in males. The intermediate and high SYNTAX score groups were similar according to the study parameters excluding gender, the NL, NC/NL, and SAD. The number of smokers was significantly higher in the intermediate SYNTAX score group. The medical histories of the patients with high SYNTAX scores revealed that these patients had smoked but stopped smoking in the past. Between the intermediate and low SYNTAX score groups, there were no significant differences by the study parameters excluding the CCuH, LVEF, EFT, and HL.

The correlation analysis has shown that SYNTAX scores significantly increase with the increases in EFT, age, height, weight, BMI, NC, NC/NL, CCuH, WC, HC, WHR, and the SAD. EFT significantly increased with low LVEF values and high values of SYNTAX scores, height, weight, BMI, NL, NC, CCuH, WC, HC, WHR, and the SAD.

The number of coronary vessels with lesions is not adequate alone to determine the severity of coronary artery disease. The location of the lesions, the effects of lesions on the blood flow, the degree of vascular stenosis, classification of lesions, the vessel diameter and calcification, technical feasibility of percutaneous coronary intervention (PCI) and the prognosis of PCI are the major factors affecting the severity of the disease (7,19,20). SYNTAX is a scoring method used for determining the anatomical structure of the coronary vessels, the severity of the disease, and the complexity of the event in coronary artery disease (21). The SYNTAX scoring system is also a highly effective method both in predicting prognosis and determining the treatment method (22). The SYNTAX scoring system is recommended in clinical guidelines and is increasingly used in daily clinical practice (21). After calculating SYNTAX scores, the obtained scores can be categorized as low (SS≤17), intermediate (SS=18-28), and high (SS≥29) score groups (23). Currently, the decision to perform whether coronary artery bypass graft (CABG) surgery or PCI is made based on the SYNTAX scores (21). PCI is an alternative to bypass surgery in patients with three-vessel disease and a SYNTAX score of ≤22. Patients with three-vessel disease and SYNTAX score ≥23 should undergo CABG (21). In this present study, the SYNTAX scores were classified under 3 categories as low (SS≤17), intermediate (SS=18-28), and high (SS≥29) score groups similar to the categorization used by Karakurt et al. (23) (Table 3). Our study results demonstrating the association of high SYNTAX scores with advanced age and higher incidences of DM, HT, and HL are compatible with the results reported by Karakurt et al. (2016) (23). However, another finding of the same study showed a significant difference in LVEF across the low, intermediate, and high SYNTAX score groups. In our study, a significant difference in LVEF was found only between the low and intermediate SYNTAX score groups (23). The correlation analysis in our study revealed that no relationships existed between the SYNTAX scores and LVEF (r=-0.05, p=0.36).

One of the strategies to reduce cardiovascular morbidity and mortality is to reveal cardiovascular risk factors (24). Obesity, type II diabetes mellitus, hypertension and dyslipidemia are risk factors for coronary heart disease (25). Anthropometric measurements have been proposed to estimate the amount and location of body fat (26). Advantages of using anthropometric parameters include ease of use, less invasiveness, and minimal costs. These advantages of anthropometric measurements provide a practical option for use in clinical settings and population studies (26,27). The results of longitudinal studies investigating the period from childhood to adulthood showed that anthropometric measurements obtained in childhood are an indicator of cardiovascular risk in adulthood (28,29). Among the suggested anthropometric indexes; BMI, WC and WHR are the most frequently studied parameters (30). Some studies have reported

the robustness of these anthropometric measurements in determining cardiovascular risks (31,32). In our study, the study parameters listed in Table 1 were compared between the control group of 70 individuals and the case group of 300 patients, who underwent angiography due to suspected coronary artery disease. The anthropometric measures, EFT, and some cardiovascular risk factors (9) were compared between the control group of 70 individuals and the case group of 300 individuals, whose SYNTAX scores (7) were calculated. Zen et al. (2012) (33) have reported that a large NC is a risk factor for coronary artery diseases in their study investigating the relationship between the NC and cardiovascular diseases. In our study, it was found that the increase in the NC was positively correlated with high SYNTAX scores and increased EFT.

EFT is associated with several parameters including age, diabetes mellitus, obesity, and hypertension. Therefore, the measurement of EFT is recommended for use in the diagnosis of cardiovascular diseases. EFT is reported to be an important parameter in determining the presence and severity of coronary artery disease (16). Abbara et al. (2006) (34) reported that EFT thickness increased with increasing age, while Lacobellis et al. (2003) (35) found no correlations between age and EFT thickness. The strong correlation of the EFT quantity with the WC was demonstrated in the study by (35). The findings in our study are compatible with the study findings of Lacobellis et al. (2003) (35) about age and the WC.

Our study has some limitations. Firstly, the data of this study represent only the central Anatolian population in Turkey. Secondly, it is a single-centre study and included only a limited number of patients.

CONCLUSION

In conclusion, we have determined that the SYNTAX score and EFT are correlated with the NC, NC/NL ratio, CCuH, WC, HC, WHR, and SAD. We found that as the SYNTAX scores increased, the measured values of these parameters increased significantly. These results show that, in addition to the SYNTAX scores, anthropometric measurements and the quantity of EFT can be used for determining the severity of coronary artery disease.

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Ethical approval: *The study was approved by the Nigde Omer Halisdemir University Non-Interventional Clinical Research Ethics Committee (Protocol number: 2019/29).*

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