Predictive value of arm circumference (AC) and arm muscle circumference (AMC) with cardiovascular risk in healthy and diabetic males

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Abstract. – OBJECTIVE: The predictive value of body simplified indices needs to be evaluated properly for cardiovascular risk. This study aimed to assess and compare the relative relationship of arm circumference (AC), arm muscle circumference (AMC), body mass index (BMI), and waist-hip ratio (WHR) with Ultra-Sensitive C-Reactive Protein (US-CRP) in healthy male subjects and with type 2 diabetes mellitus (T2DM).

PATIENTS AND METHODS: We performed the study at the department of Physiology, College of Medicine & King Khalid University Hospital, King Saud University, Riyadh, Saudi Arabia. It was a cross-sectional study with 93 healthy male subjects and 112 type 2 diabetic male patients who underwent body composition analysis by BIA and fasting venous blood samples were collected. US-CRP and body composition were determined for all subjects.

RESULTS: US-CRP is correlated positively with AC (0.378) and BMI (0.394) more than AMC (0.282) and WHR (0.253) which have lower correlation both in control and DM group. BCM has the lowest correlation with US-CRP (0.105). The association between US-CRP and AC, AMC, Body Fat Percent (BFP), and body fat mass (BFM) are statistically significant except for BFP in DM group. In control group, AC is noticed to be a better predictor for US-CRP, with area under curve (AUC) 64.2% (*p*=0.019), WHR with AUC 72.6% (*p*<0.001), and BMI with AUC 65.4% (*p*=0.011) but AMC is not a good predictor in control group with AUC 57.5% (*p*=0.213). In DM group, AC is noticed to be a better predictor for US-CRP, with AUC 71.5% (*p*<0.001), WHR with AUC 67.4% (*p*=0.004), BMI with AUC 70.9% (*p*=0.001), and AMC with AUC 65.2% (*p*=0.011).

CONCLUSIONS: Simplified muscle mass body indices like AC and AMC have significant predictive value for assessing cardiovascular risk in both healthy population and patients with T2DM. Therefore, AC could be used as a future predictor for cardiovascular disease in healthy and DM patients. Further investigations are needed to confirm its applicability.

Key Words:

US-CRP, Arm circumference, Arm muscle circumference, Body fat mass, Body mass index, Waist-hip ratio.

Introduction

Anthropometric measurements are noninvasive quantitative measurements of the human body that can provide valuable insights into nutritional as well as health status in children and adults[1,2]. In addition, they can be used to predict risk of future illnesses in adults and can also be used to assess body composition[1-3]. Several anthropometric measurements such as body mass index (BMI) and waist circumference (WC) have been found to be predictors of cardiovascular risk[2-4]. Arm circumference (AC) and arm muscle circumference (AMC) have been mentioned in the literature as anthropometric measurements[1,5,6], and studies[5,6] have observed correlation of AC and AMC with mortality of various diseases.

Chronic low-grade inflammation can progress to the development of chronic diseases without being noticed by the patients and subsequently an overall increase in mortality[7]. This necessitates the need of markers that can predict cardiovascular risk to prevent such diseases. Ultra-sensitivity C-reactive protein (US-CRP), which is commonly known as hs-CRP, is an acute phase protein synthesized by the liver and increases in response to systemic inflammation[8]. Elevated levels of Ultra sensitivity c-reactive protein (US-CRP) have been established to be associated with an increased risk of cardiovascular disease[9].

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Even with the advanced treatment and control of diabetes mellitus (DM), cardiovascular diseases are still the leading causes of morbidity and mortality in DM patients[10-12]. Approximately 40% of death in DM patients is due to ischemic heart disease, 15% is due to congestive heart failure, and around 10% from stroke,[13-16] while ischemic heart disease is counted for 16% of total deaths among all diseases[17].

As mentioned earlier, some indices are known to predict cardiovascular disease in humans such as US-CRP, while other indices need to be evaluated in order to depend on them as predictor indices. In addition, their sensitivity and specificity as noninvasive indices needs to be assessed properly. This study aimed to assess and compare the relationship of arm circumference (AC), arm muscle circumference (AMC), body mass index (BMI), and waist-hip ratio (WHR) with US-CRP in healthy subjects and patients with type 2 diabetes mellitus.

Patients and Methods

We performed the study at the department of Physiology, College of Medicine and King Khalid University Hospital, King Saud University, Riyadh, Saudi Arabia. It was cross sectional study with 93 healthy male subjects and 112 type 2 diabetic male patients. All subjects were not in inflammatory conditions. Sociodemographic characteristics of sample size were obtained from patient's records. We collected blood samples after overnight fasting, then serum was separated and stored at –80 °C until assayed as a single batch. To measure US-CRP, we used a turbidimetric assay (Quantex CRP ultra-sensitive kits, BIOKIT, S.A., Barcelona, Spain) on auto-analyzer Hitachi 911, (ROCHE diagnostics, Indianapolis, IN, USA). The US-CRP kits measured ranges from 0.10 to 20.0 mg/L). We measured anthropometric and body composition for all subjects in the morning after overnight fasting and wearing light clothes. Regarding Body composition, it was assessed by using bioelectrical impedance analysis (BIA), a commercially available body analyzer (TANITA, USA). We calculated body surface area using the Mosteller formula: (SQR [body weight (kg)×Height (cm)/3600]).

Subjects' Enrolment

Selection criteria

Adult healthy male for control group and male patients with type 2 diabetes mellitus for diabetic group were selected.

We excluded subjects with acute or chronic renal, thyroid disorders, acute infections, recent stroke, diabetic ketoacidosis.

Statistical Analysis

Data analysis was performed using SPSS [SPSS, Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY, USA)]. Descriptive data are expressed as mean ± SD. Normally distributed continuous data groups were compared by the *t*-test. Correlation was determined by Spearman's correlation analysis for serum US-CRP and WHR, BMI, AMC, AC, and BCM. We also performed a linear regression analysis with US-CRP as dependent variable and AC, AMC, BCM, BFP and BFM as predictors to compare the predictive value of each variable after controlling age, SBP and DBP. Statistical significance was defined as a p-value of <0.05 and <0.01. ROC curve analysis was performed to evaluate the comparative predictive value of AC, AMC, WHO, and BMI scores with US-CRP.

Results

Table I shows the mean and standard deviation of demographic characteristics of the sample size. The mean age of control group is 40.5±12.7 while DM group is 52.8±10.4. It shows statistically significant difference between control group and DM group in BMI (27.8±5.0 *vs.* 29.6±5.0 with p=0.014), WHR (0.9±0.1 *vs.* 1.0±0.0 with p<0.001), AC (32.6±4.0 *vs.* 34.2±4.4 with p=0.008), AMC (24.7±2.5 *vs.* 25.6±2.3 with p= 0.009), fat mass (23.7±9.0 *vs.* 26.8±10.4 with p=0.022) with no significant difference in BCM (39.5±6.7 *vs.* 40.0±5.6 with p=0.594).

Table II shows the biochemistry parameters of study population. It also shows statistical significant difference between control group and DM group in TC (4.9±1.1 *vs.* 4.3±1.2 with p<0.001), LDL (3.3±0.9 *vs.* 2.7±0.9 with p<0.001), HDL (1.2±0.2 *vs.* 1.0±0.3 with p<0.001), TG (1.0±0.4 *vs.* 2.0±1.4 with p< 0.001), US-CRP (3.7±2.5 *vs.* 4.7±3.0 with p=0.009), Fasting blood glucose (5.0±0.5 *vs.* 8.6±3.0 with p<0.001), and HbA1C (5.0±0.5 *vs.* 7.7±1.4 with p<0.001).

Table III shows the correlation of US-CRP with WHR, BMI, AMC, AC, And BCM. US-CRP is more correlated positively with AC (0.378) and BMI (0.394) than AMC (0.282) and WHR (0.253) which have less correlation in control and DM group. BCM has the lowest correlation with US-CRP (0.105).

Table I. Demographic characteristics of total sample and comparison between healthy and T2DM.

Variables	Total, N=205	Control, n=93	DM, n=112	*p*-value
Age (years)	47.2±13.0	40.5±12.7	52.8±10.4	<0.001*
BMI(Kg/M^2)	28.8±5.1	27.8±5.0	29.6±5.0	0.014*
WHR	0.9±0.1	0.9±0.1	1.0±0.0	<0.001*
AC	33.4±4.3	32.6±4.0	34.2±4.4	0.008*
AMC	25.2±2.4	24.7±2.5	25.6±2.3	0.009*
BCM	39.9±6.1	39.5±6.7	40.0±5.6	0.594
BFM (KG)	25.4±9.9	23.7±9.0	26.8±10.4	0.022*

Data are represented as mean and standard deviation. * is significant. BMI: body mass index; WHR: waist/hip ratio.

Table II. Biochemical profile of total sample and comparison between healthy and T2DM.

Variables	Total, N=205	Control, n=93	DM, n=112	*p*-value
TC (mmol/L)	4.6±1.2	4.9±1.1	4.3±1.2	0.001*
LDL(mmol/L)	3.0±0.9	3.3±0.9	2.7±0.9	<0.001*
HDL(mmol/L)	1.1±0.2	1.2±0.2	1.0±0.3	<0.001*
TG(mmol/L)	1.5±1.2	1.0±0.4	2.0±1.4	<0.001*
US-CRP mg/L	4.3±2.8	3.7±2.5	4.7±3.0	0.009*
FBG mmol/L	7.0±2.9	5.0±0.5	8.6±3.0	<0.001*
HbA1C	6.5±1.7	5.0±0.5	7.7±1.4	<0.001*

Data are represented as Mean and standard deviation. *is significant. FBS: fasting blood sugar; TC: total cholesterol; TG: triglycerides; LDL low-density lipoprotein; HDL: high-density lipoprotein.

Linear regression analysis is performed to evaluate the association of US-CRP as the dependent variable with AC, AMC, BFP, and BFM in total sample, control group, and DM in Table IV. The association is statistically significant for AC, AMC, BFP, and BFM except BFP in DM group.

Table V represents ROC curve analysis which reveals a sensitivity of approximately 80% and specificity of approximately 39-50% of AC at a cutoff point of 31.500 when compared to US-CRP, a sensitivity of approximately 80% and specificity of approximately 47-51% of BMI at a cutoff point of 26.100-27.300 when compared to US-CRP, a sensitivity of approximately 80% and specificity of approximately 21-28% of AMC at a cutoff point of 23.00 when compared to US-CRP, and a sensitivity of approximately 79%, and specificity of approximately 44-51% of WHR at a cutoff point of 0.935 when compared to US-CRP.

Table III. Correlation coefficients of US-CRP relationship with various indices.

Index	Total, N=205	Control, n=93	DM, n=112
WHR	0.253**	0.167	0.300**
BMI	0.394**	0.361**	0.388**
AMC	0.282**	0.234*	0.277**
AC	0.378**	0.326**	0.374**
BCM	0.105	0.093	0.109
BFP	0.371**	0.362**	0.365**
BFM	0.390**	0.341**	0.397**

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

Figure 1 and Table VI show ROC curve analysis to evaluate the predictive value of AC, AMC, WHO, and BMI with US-CRP. AC is noticed to be a better predictor for US-CRP, with area under the curve (AUC) 68.5% (p<0.001), WHR with AUC 71.7% (p<0.001), BMI with AUC 69.0% (p<0.001), and AMC with AMC with AUC 62.8% (p=0.002). Figure 2 and Table VI show ROC curve analysis to evaluate the predictive value of AC, AMC, WHO, and BMI with US-CRP in control group. AC is noticed to be a better predictor for US-CRP, with AUC 64.2% (p=0.019), WHR with AUC 72.6% (p<0.001), and BMI with AUC 65.4% (p=0.011) but AMC is not a good predictor in control group with AUC 57.5% (p=0.213). Figure 3 and Table VI show ROC curve analysis to evaluate the predictive value of AC, AMC, WHO, and BMI with US-CRP in DM group. AC is noticed to be a better predictor for US-CRP, with AUC 71.5%

Table IV. Regression Models with US-CRP as dependent variable and body indices as predictors of cardiovascular risk.

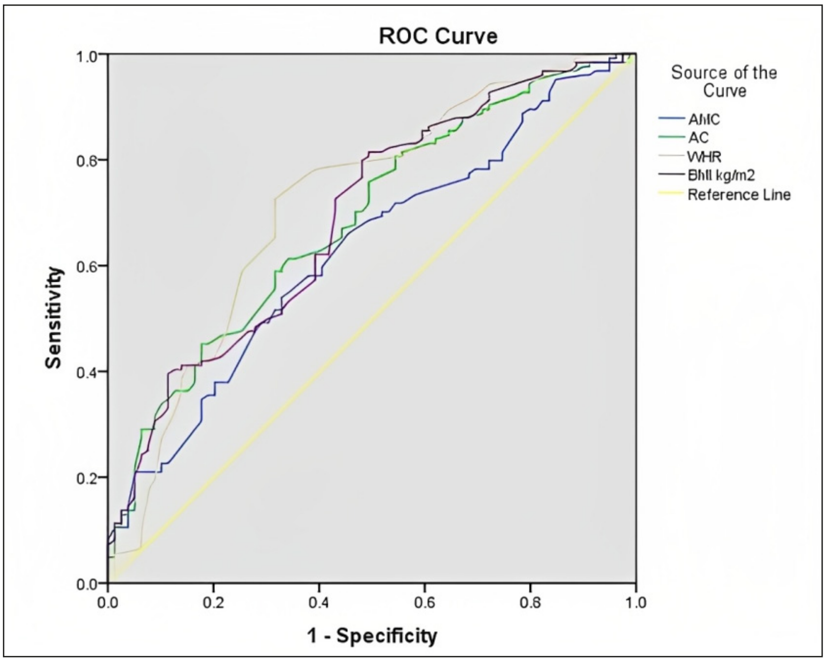
Predictors	Unstandardized β Coefficients	Standardized β Coefficients	T	Sig.	95.0% Confidence Interval	
					Lower Bound	Upper Bound
Total sample						
AC	0.244	0.372	5.624	<0.001	0.158	0.329
AMC	0.322	0.280	4.111	<0.001	0.168	0.477
BFP	0.066	0.222	3.175	0.002	0.025	0.107
BFM	0.110	0.381	5.799	<0.001	0.073	0.147
WHR	5.596	0.244	3.532	0.001	2.472	8.720
BMI	0.216	0.386	5.888	<0.001	0.144	0.288
Control						
AC	0.193	0.314	3.108	0.003	0.070	0.316
AMC	0.231	0.236	2.310	0.023	0.032	0.430
BFP	0.106	0.330	2.997	0.004	0.036	0.176
BDM	0.096	0.345	3.338	0.001	0.039	0.153
WHR	2.522	0.151	1.465	0.146	-0.899	5.942
BMI	0.168	0.339	3.330	0.001	0.068	0.269
DM						
AC	0.261	0.382	4.073	<0.001	0.134	0.388
AMC	0.357	0.276	2.854	0.005	0.109	0.605
BFP	0.043	0.150	1.580	0.117	-0.011	0.096
BFM	0.112	0.382	4.163	<0.001	0.059	0.165
WHR	10.970	0.304	3.294	0.001	4.368	17.572
BMI	0.237	0.391	4.246	<0.001	0.126	0.348

Data are represented as mean and standard deviation. * is significant. BMI: body mass index; WHR: waist/hip ratio.

Table V. Sensitivity and specificity for best cutoff points of AC, BMI, ACM, and WHR (ROC analysis between AC, BMI, ACM, and WHR and US-CRP.

Parameter	Cutoff Point	Sensitivity (%)	Specificity (%)
Total sample			
AC	31.500	80.6	45.6
BMI	26.900	80.6	50.6
AMC	23.050	81.5	25.3
WHR	0.935	80.6	44.3
Control			
AC	31.500	80.4	50.0
BMI	26.100	80.4	47.8
AMC	23.050	80.4	28.3
WHR	0.925	78.3	50.0
DM			
AC	31.400	80.8	39.4
BMI	27.300	80.8	48.5
AMC	23.550	80.8	21.2
WHR	0.955	79.5	51.5

Figure 1. ROC curve for Us-CRP as dependent variable and AC, AMC and BMI as predictors in total sample size.



(p<0.001), WHR with AUC 67.4% (p=0.004), BMI with AUC 70.9% (p=0.001), and AMC with AUC 65.2% (p=0.011).

Discussion

Cardiovascular diseases were behind around 32% of the deaths globally according to the declaration of World Health Organization (WHO) in 2019[12], and it will exceed the death rates of various causes including infection, maternal, perinatal, and nutrition in 2030[18,19].

Furthermore, diabetes mellitus (DM) is considered to be a major health issue among health care providers as well as decision makers especially if we know that an approximate estimation of 650 million might have DM by 2030[15,16,20-23].

Table VI. ROC curve analysis for Us-CRP as dependent variable and AC, AMC and BMI as predictors in total sample size, control, and DM.

Test result Variable (s)	Area	*p*-value	95% Confidence Interval	
			Lower Bound	Upper Bound
Total sample				
AMC	0.628	0.002	0.551	0.705
AC	0.685	<0.001	0.612	0.759
WHR	0.717	0.000	0.642	0.791
BMI kg/m^2	0.690	0.000	0.616	0.764
Control				
AMC	0.575	0.213	0.458	0.693
AC	0.642	0.019	0.529	0.756
WHR	0.726	<0.001	0.621	0.830
BMI kg/m^2	0.654	0.011	0.541	0.766
DM				
AMC	0.652	0.011	0.547	0.758
AC	0.715	<0.001	0.616	0.814
WHR	0.674	0.004	0.559	0.789
BMI kg/m^2	0.709	0.001	0.609	0.809

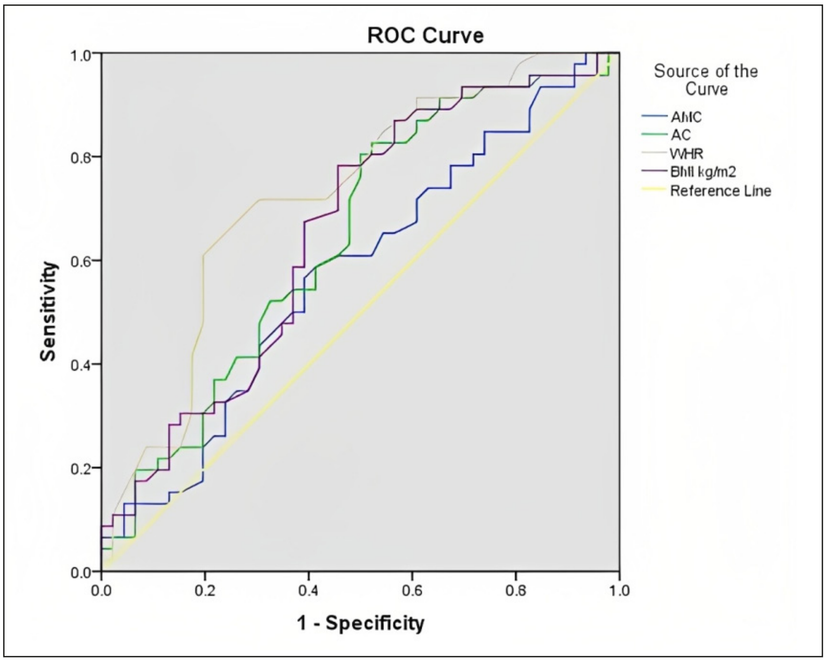


Figure 2. ROC curve for Us-CRP as dependent variable and AC, AMC and BMI as predictors in control group.

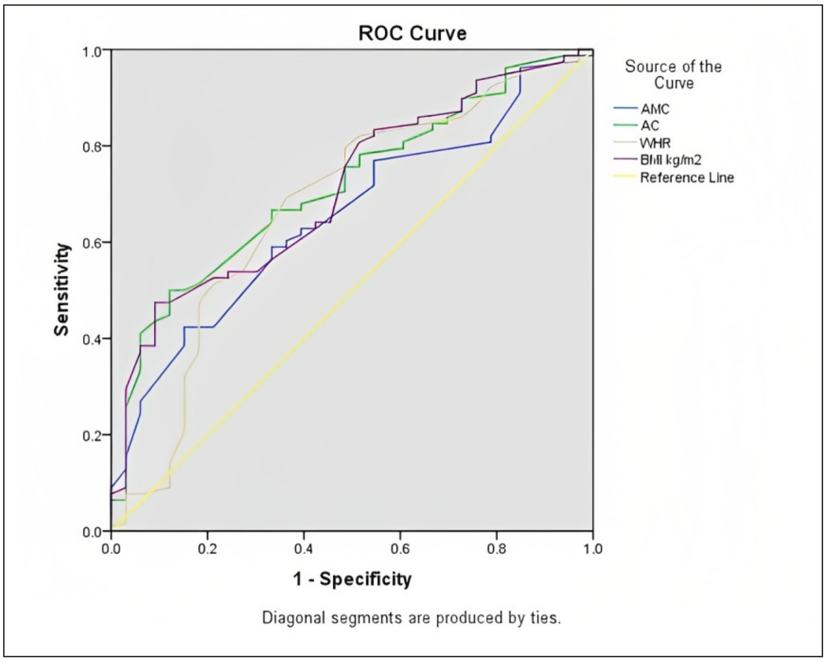


Figure 3. ROC curve for Us-CRP as dependent variable and AC, AMC and BMI as predictors in DM group.

Elevation in serum US-CRP is a well-known predictor of cardiovascular disorders[24-26]. In addition, a high level of US-CRP was observed in type 2 diabetes mellitus (T2DM) patients[27]. Our results addressed the correlation between US-CRP (as a well-known cardiovascular predictor) and AC, AMC, BMI, AND WHR in healthy and DM patients. US-CRP was correlated positively with AC, AMC, BMI, and WHR with more correlation with AC and BMI. BCM has the lowest correlation with USCRP. Furthermore, AC had more specificity than AMC and had approximate specificity to BMI and WHR while AMC had lower specificity. One can notice from our results that AC and AMC had produced similar results in healthy subjects as well as diabetic patients which can simply explain their decrease in specificity. Our results were not fully consistent with the findings of Noori et al[28], who found a positive correlation between AMC and better quality of life while

Wu et al[5] found a negative correlation between AMC and risk of mortality in males but not in females. This was also different than our results which found a positive correlation of AMC and US-CRP in male subjects. Chang et al[29] also suggested different results from what we have found: negative correlation with mortality rate. Even though our results suggested less correlation between AMC and US-CRP, still there was positive correlation which needs further investigation and clarification. However, our results were consistent with findings of Chao et al[30] who found positive correlation between AMC and HOMA-IR, known to be correlated with cardiovascular diseases, in non-obese subjects with no correlation in obese subjects.

Conclusions

Simplified muscle mass body indices like AMC and AC have differential predictive value for assessing cardiovascular risk in both heathy population and patients with T2DM. Therefore, AC could be used as a future predictor for cardiovascular disease in DM patients. Further investigation is needed to confirm its applicability.

Conflict of Interest

None.

Funding

The authors extend their appreciation to the Deputyship for Research & Innovation, Ministry of Education in Saudi Arabia for funding this research work through the project number IFKSURG-192. The funding body played no role in the design of the study and data collection, analysis, interpretation or writing of the manuscript.

Ethics Approval

It was approved by the Ethical Committee of College of Medicine Research Center (CMRC), King Saud University, Riyadh, Saudi Arabia.

Data Availability

Data is available upon formal request from the primary investigator.

Informed Consent

All participants signed consent forms and informed about confidentiality and rights.

Authors' Contributions

SSH, TAK: study design, study supervision, writing, and editing the manuscript. SMH, HTK, MBA, NAA, NAA: data collection, and statistical analysis.

References

1) Casadei K, Kiel J. Anthropometric Measurement. 2021 Oct 1. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022.
2) Tabary M, Cheraghian B, Mohammadi Z, Rahimi Z, Naderian MR, Danehchin L, Paridar Y, Abolnejadian F, Noori M, Mard SA, Masoudi S, Araghi F, Shayesteh AA, Poustchi H. Association of anthropometric indices with cardiovascular disease risk factors among adults: a study in Iran. Eur J Cardiovasc Nurs 2021 22; 20: 358-366.
3) Mahdavi-Roshan M, Rezazadeh A, Joukar F, Naghipour M, Hassanipour S, Mansour-Ghanaei F. Comparison of anthropometric indices as predictors of the risk factors for cardiovascular disease in Iran: The PERSIAN Guilan Cohort Study. Anatol J Cardiol 2021; 25: 120-128.
4) Vidal Martins M, Queiroz Ribeiro A, Martinho KO, Silva Franco F, Danésio de Souza J, Bacelar Duarte de Morais K, Gonçalves Leite IC, Araújo Tinôco AL. Anthropometric indicators of obesity as predictors of cardiovascular risk in the elderly. Nutr Hosp 2015 1; 31: 2583-2589.
5) Wu LW, Lin YY, Kao TW, Lin CM, Liaw FY, Wang CC, Peng TC, Chen WL. Mid-arm muscle circumference as a significant predictor of all-cause mortality in male individuals. PLoS One 2017 14; 12: e0171707.
6) Wu LW, Lin YY, Kao TW, Lin CM, Wang CC, Wang GC, Peng TC, Chen WL. Mid-Arm Circumference and All-Cause, Cardiovascular, and Cancer Mortality among Obese and Non-Obese US Adults: the National Health and Nutrition Examination Survey III. Sci Rep 2017 23; 7: 2302.
7) De Martinis M, Franceschi C, Monti D, Ginaldi L. Inflammation markers predicting frailty and mortality in the elderly. Exp Mol Pathol 2006 80: 219-227.
8) Pepys M, Hirschfield G. C-reactive protein: a critical update. J Clin Invest 2003; 111: 1805-1812.
9) Li Y, Zhong X, Cheng G, Zhao C, Zhang L, Hong Y, Wan Q, He R, Wang Z. Hs-CRP and all-cause, cardiovascular, and cancer mortality risk: A meta-analysis. Atherosclerosis 2017; 259: 75-82.
10) Booth G, Kapral M, Fung K, Tu J. Relation between age and cardiovascular disease in men and women with diabetes compared with non-diabetic people: a population-based retrospective cohort study. Lancet 2006; 368: 29-36.
11) Beckman J, Paneni F, Cosentino F, Creager M. Diabetes and vascular disease: pathophysiology, clinical consequences, and medical therapy: part II. Eur Heart J 2013; 34: 2444-2452.

12) World Health Organization. [Accessed December 17, 2015] cardiovascular diseases (CVDs) Fact sheet No 317. Internet. 2015 Jan. Available at: URL: http://www.who.int/mediacentre/factsheets/fs317/en/
13) Tancredi M, Rosengren A, Svensson AM, Kosiborod M, Pivodic A, Gudbjörnsdottir S, Wedel H, Clements M, Dahlqvist S, Lind M. Excess Mortality among Persons with Type 2 Diabetes. N Engl J Med 2015 29; 373: 1720-1732.
14) Wang C, Hess C, Hiatt W, Goldfine A. Clinical Update: Cardiovascular Disease in Diabetes Mellitus: Atherosclerotic Cardiovascular Disease and Heart Failure in Type 2 Diabetes Mellitus - Mechanisms, Management, and Clinical Considerations. Circulation 2016 14; 133: 2459-2502.
15) Zhou C, Byard RW. An Analysis of The Morbidity and Mortality of Diabetes Mellitus in a Forensic Context. J Forensic Sci 2018; 63: 1149-1154.
16) Mulnier H, Seaman H, Raleigh V, Soedamah-Muthu S, Colhoun H, Lawrenson R. Mortality in people with type 2 diabetes in the UK. Diabet Med 2006; 23: 516-521.
17) The top 10 causes of death [Internet]. World Health Organization. World Health Organization; [cited 2022Mar14]. Available at: https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death.
18) Beaglehole R, Bonita R. Global public health: a scorecard. Lancet 2008; 372: 1988-1996.
19) World Health Organization. A Vital Investment. World Health 2005; 202.
20) International Diabetes Federation (IDF). Diabetes Facts and Figures, Atlas, 10 editions. Available at: https://www.idf.org/aboutdiabetes/what-is-diabetes/ facts-figures.html.
21) Al-Khlaiwi T, Alsabih A, Khan A, Habib SS, Sultan M, Habib SH. Reduced pulmonary functions and respiratory muscle strength in Type 2 diabetes mellitus and its association with glycemic control. Eur Rev Med Pharmacol Sci 2021; 25: 7363-7368.
22) Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: Estimates for the year 2000 and projections for 2030 [Internet]. Diabetes care. U.S. National Library of Medicine. Available from: https://pubmed.ncbi.nlm.nih.gov/15111519/
23) Diabetes [Internet]. World Health Organization. World Health Organization. Available from: https://www.who.int/health-topics/diabetes#tab=tab_1
24) Al Aseri Z, Habib SS, Marzouk A. Predictive value of high sensitivity C-reactive protein on progression to heart failure occurring after the first myocardial infarction. V asc Health Risk Manag 2019; 15: 221-227.
25) Aseri Z, Habib SS, Alhomida A, Khan H. Relationship of high sensitivity C-reactive protein with cardiac biomarkers in patients presenting with acute coronary syndrome. J Coll Physicians Surg Pak 2014; 24: 387-391.
26) Habib SS, Al Masri A. Relationship of high sensitivity C-reactive protein with presence and severity of coronary artery disease. Pak J Med Sci 2013; 29: 1425-1429.
27) Habib SS, Al-Regaiey K, Al-Khlaiwi T, Habib S, Bashir S, Al-Hussain F, Habib S. Serum inducible and endothelial nitric oxide synthase in coronary artery disease patients with Type 2 Diabetes mellitus. Eur Rev Med Pharmacol Sci 2022; 26: 3695-3702.
28) Noori N, Kopple JD, Kovesdy CP, Feroze U, Sim JJ, Murali SB, Luna A, Gomez M, Luna C, Bross R, Nissenson AR, Kalantar-Zadeh K. Mid-arm muscle circumference and quality of life and survival in maintenance hemodialysis patients. Clin J Am Soc Nephrol 2010; 5: 2258-2268.
29) Chang P, Chen W, Wu L. Mid-arm muscle circumference: A significant factor of all-cause and cancer mortalities in individuals with elevated platelet-to-lymphocyte ratio. PLoS One 2018 13; 13: e0208750.
30) Chao YP, Lai YF, Kao TW, Peng TC, Lin YY, Shih MT, Chen WL, Wu LW. Mid-arm muscle circumference as a surrogate in predicting insulin resistance in non-obese elderly individuals. Oncotarget 2017 18; 8: 79775-79784.