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Risk Factors in Nutritional Status of Cardiovascular Patients As A Potential Indicator Before The Development of Heart Failure Signs

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ABSTRACT

Cardiovascular disease (CVD) is related to many risk factors like unhealthy dietary pattern and physical inactivity. Dietary modification has been involved in managing and reducing the risk of CVD. The current study aimed to investigate the association of obesity and nutritional status with clinical characteristics, echocardiographic changes, and clinical outcomes in a random sample of 54 individuals aged between 30-60 years enrolled from the outpatient cardiology clinic in Ain Shams University hospital. Study participants were classified into five groups according to heart disease status (normal control, metabolic syndrome, risk factor, compensated CVD, decompensated CVD). A standardized 24-four-hour questionnaire was used to determine dietary intake. Anthropometric measurements, biochemical analysis and echocardiography examination were done for all study subjects. Overall and central obesity was highly prevalent among the metabolic syndrome, risk factor and decompensated CVD groups compared to the other groups. We found that obese individuals with poor nutritional status have the highest comorbidity burden, the most adverse cardiac remodeling, and the least favorable composite outcome. Therefore, increasing public awareness of healthy lifestyle and dietary patterns to enhance the prevention of CVD and associated risk factors.

Keywords: Cardiovascular risk, Dietary intake, Anthropometric, Biochemical, Echocardiography

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INTRODUCTION

Cardiovascular disease (CVD) is the leading cause of mortality worldwide **(WHO, 2014)**. It is anticipated that CVD will remain the leading global cause of mortality, resulting in approximately 23 million deaths by 2030 **(Mathers and Loncar, 2006)**.

Regarding prevention measures, it is estimated the adoption of healthy lifestyle choices reduces the risk of myocardial infarction by 81–94% **(Akesson et al., 2007; Yusuf et al., 2004; Ford et al., 2009)**, whereas treatment with pharmacotherapies alone results in a 20–30% reduction **(Chiuve et al., 2006)**. Accordingly, nutrition is the most important behavioral factor in preventing premature CVD death and disability, surpassing smoking abstinence and physical activity **(Kahleova et al., 2018)**.

Atherosclerosis represents an inflammatory process characterized by a complex, dysfunctional interplay between the immune system and lipids, while both can be affected by dietary habits **(Tousoulis et al., 2016)**. Providing more support for the close link between dietary factors and

inflammation, the adoption of plant-based diets has demonstrated significant effects on inflammatory biomarkers **(Grosso et al., 2022)**.

Excessive energy consumption and fat intake increases the risk of obesity and may, paradoxically, be combined with deficiency of essential micronutrients. This may be the result of unhealthy eating habits along with malabsorption and altered metabolism of micronutrients following low-grade systemic inflammation promoted by obesity **(Kobyli´nska et al., 2022)**.

Diet quality level decreases with socioeconomic status, which is reflected in the higher prevalence of overweight and obesity **(Gómez et al., 2021)**. Likewise, dietary and behavioral aberrations, along with insufficient access to modern therapeutic modalities, are considered to partially account for high cardiovascular disease prevalence among individuals of lower socioeconomic status .

Without overlooking integrated management of classical risk factors, educational interventions aiming to improve eating behaviors are crucial to reducing cardiovascular disease **(Ramôa Castro et al., 2017)**.

The objective of the present study was to identify the subtle role of malnutrition in building up cardiovascular risk factors and resulting in deterioration of overt cardiac disease.

MATERIALS AND METHODS

Study Population:

The study was a prospective observational pilot study which included patients referred to the cardiology clinic in the Cardiology Department Ain Shams University Hospital in the period from January 2020 to June 2021. Out of 85 patients referred to the clinic in the specified period of time, 54 patients (29 males and 25 females) were enrolled in the study after obtaining an informed consent (5 patients were excluded as they underwent bariatric surgeries, 4 ladies were excluded as they were pregnant, 2 ladies were excluded as they were lactating, 5 patients were excluded as they suffered type 1 diabetes, 7 patients were excluded as they underwent recent open heart surgery within 6 months, 1 patient was excluded as he suffered cancer esophagus with difficult swallowing and was receiving chemotherapy, 3 patients were excluded as they suffered autoimmune disorders and were receiving high doses of steroids, while, the rest of patients were not cooperative during achievement the study). The study populations were classified into five groups as follow in Table (1):

Table 1. Classification of participants according to heart disease status

Patients Groups	No.	%
1. Normal individuals	9	16.67
2. Metabolic syndrome	7	12.96
3. Risk factor	11	20.37
4. Compensated cardiac	11	20.37
5. Decompensated cardiac	16	29.63
Total	54	100

Dietary assessment:

Nutritional intake was assessed by twenty-four-hour recall questionnaire via three-day food records were collected, including (2 non- consecutive weekdays and 1 weekend day). The total calorie intake as well as the total amount of macro- and micronutrients consumed by each patient

were calculated using the food analysis composition tables and compared to the percentage of their intake with the recommended daily allowance (RDA) according to **(The National academies of sciences, 2011)**.

Anthropometric measurements:

Anthropometric measurements included body weight and height of everyone were recorded using digital body weight balance "Heca Germany" available at Cardiology Department, Ain Shams University Hospital, Cairo, Egypt. Also, waist as well as hip circumferences were measured by anthropometric tape, while the central obesity was checked in the respondents using waist-to-hip ratio, WHtR (waist-to-height ratio) and body mass index (BMI) were also calculated according to the techniques described by (**WHO, 2008; Lee et al., 2008; Whitney et al., 2010)**.

Biochemical analysis:

Blood samples were obtained from all the study participants after fasting for 9-12 hours. Sample for Lipid profile analysis: Including serum blood levels of total cholesterols, high density lipoprotein and low-density lipoprotein were assayed according to **(Artiss and Zak, 1997)**. Glycated heamoglobin (HbA1C) mg/dl measured by standard methods as described by **(Jan-Olof et al., 2002)**. Kidney function: Including serum blood urea nitrogen and serum creatinine was analysed according to **(Tietz, 1994)**, serum uric acid as described by **(Shultz, 1984)**. While homocysteine was assayed according to **(Boushey et al., 1995)**.

Standard Echocardiography Protocol:

All patients were subjected to transthoracic echocardiographic evaluation using GE Vivid S6 echo machine and 3.5 MHz probe. All patients were studied in the left lateral decubitus position by an expert cardiologist using an ultrasound system. A full transthoracic echocardiographic study was performed for each patient in the standard views including apical 4-chamber, apical 5-chamber, parasternal long axis & parasternal short axis view. The study will show special emphasis on the following echocardiographic parameters:

Assessment of left ventricular (LV) systolic function was done with the measurement of ESD (End Systolic Dimension), EDD (End Diastolic Dimension), FS (Fractional Shortening & EF (ejection fraction), **(Lang et al., 2005)**, Evaluation of LV diastolic function included assessments of LV inflow velocity pattern as well as LA diameter **(Masuyama et al., 1997)**.

Cardiac and Aortic valves assessment was done where mitral valve morphology evaluation was done using 2D echo including thickness and leaflet motion. Mitral valve Doppler flow evaluation using pulsed wave Doppler, color flow Doppler for assessment of presence or absence of mitral regurgitation (MR) and Aortic regurgitation (AR) with grading form grade 1 to 4 according to **(ACC/AHA Guideline, 2008)**.

The presence or absence of pulmonary hypertension. Estimation of pulmonary artery systolic pressure by continuous wave Doppler application over tricuspid valve, during ventricular systole,

Statistical analysis:

All data were expressed as the mean ± SE and they were analysed statistically using the one-way analysis of variance ANOVA followed by Duncan's test. In all cases $p<0.05$ was used as the criterion of statistical significance by SAS program **(SAS, 1996)** according to the procedure reported by **Steel et al., (1997)**.

RESULTS AND DISCUSSION

Daily energy and macronutrients intake of participants:

Table (2) showed that the highest calories consumption was in the normal group and the risk factor group (3810 & 3902 Kcal respectively) and was statistically significant than the rest of the groups and this could be explained for the normal group by depending on the high calorie away from home (Take-away) diets that carries future cardiac risk as well as explaining the building of cardiac risk factors in the risk factor group that will push them to more advance serious cardiac diseases.

Similar data was presented by **Wagh and Sones (2004)** who found that beside drug therapy, lifestyle therapies that combine energy restriction and physical activity independently improve a number of cardiovascular disease risk factors including insulin resistance, impaired glucose tolerance, dyslipidaemia and hypertension.

Our study showed that inspite that total daily amount of calories from proteins should not exceed 15% Kcal, all the study groups exceeded the RDA specially the decompensated and compensated cardiac groups and this was statistically significant than rest of groups.

In The Kuopio Ischaemic Heart Disease Risk Factor Study a population-based cohort study in middle-aged and older men from eastern Finland conducted by **(Heli et al., 2018)**, found that excessive intake from protein linked with increased risk of heart failure (HF).

Table 2. Energy and Macronutrients consumed by participants according to heart disease status

Energy and Macronutrients	Normal individuals	Metabolic syndrome	Risk factor patients	Compensated cardiac patients	Decompensated cardiac patients
Energy, Kcal	3810.8 ±3.2^{a}	2677.7 ±2.55^{b}	3902 ±4.52^{a}	2679.3 ±2.34^{b}	2730.6 ±2.02^{b}
Protein, g	178.36 ±1.08^{a}	131.26 ±1.80^{a}	171.43 ±2.31^{a}	143.6 ±1.93^{a}	145.54 ±1.29^{a}
% Kcal	18.88 ±0.57^{ab}	19.80 ±0.74^{ab}	17.49 ±1.35^{b}	21.66 ±0.77^{a}	21.06 ±1.02^{a}
Carbohydrate, g	428.28 ±4.57^{a}	336.64 ±1.88^{a}	429.73 ±1.31^{a}	295.59 ±1.89^{a}	308.50 ±2.25^{a}
% Kcal	46.08 ±2.24^{a}	50.79 ±1.57^{a}	44.38 ±4.30^{a}	43.49 ±2.44^{a}	45.38 ±2.16^{a}
Total fat, g	159.23 ±2.87^{a}	94.41 ±1.64^{c}	152.05 ±2.45^{ab}	107.66 ±1.83^{b}	97.99 ±1.82^{bc}
% Kcal	36.38 ±2.15^{a}	31.14 ±1.46^{a}	33.56 ±3.42^{a}	36.57 ±2.43^{a}	31.50 ±1.94^{a}

The values in the same row with different superscript letters are significantly different ($p \leq 0.05$)

Daily nutrient intake of vitamins for participants:

Table (3) shows deficiency of vitamin D intake throughout the whole study groups not exceeding 5 µg/day while the RDA should exceed 15 µg/day, our findings is concordant with **(Reid et al., 2012)** who found that vitamin D deficiency has been associated with clinical atherosclerosis in coronary calcification as well as with cardiovascular events such as myocardial infarction, stroke, and congestive heart failure. Several clinical studies have generally demonstrated an independent association between vitamin D deficiency and various manifestations of degenerative CVD such as vascular calcification.

Table 3. Daily Vitamins intakes of participants according to heart disease status

Vitamins	Normal individuals	Metabolic syndrome	Risk factor patients	Compensated cardiac patients	Decompensated cardiac patients
Vitamin D, µg	3.37 ±0.87[a]	3.95 ±1.29[a]	3.38 ±0.92[a]	4.48 ±0.83[a]	4.02 ±0.79[a]
% of RDA	22.48 ±1.77[a]	26.34 ±1.58[a]	22.52 ±1.13[a]	29.89 ±1.52[a]	26.80 ±1.32[a]
Vitamin E, mg	7.86 ±0.73[a]	6.09 ±0.51[ab]	6.35 ±0.77[ab]	4.87 ±0.3[b]	5.56 ±0.65[b]
% of RDA	52.39 ±1.86[a]	40.66 ±1.40[ab]	42.34 ±1.16[ab]	32.44 ±1.01[b]	37.08 ±1.35[b]
Vitamin K, µg	86.11 ±1.95[a]	72.92 ±1.87[a]	84.46 ±1.23[a]	65.78 ±1.89[a]	59.04 ±1.93[a]
% of AI	84.81 ±1.94[a]	74.3 ±1.39[ab]	76.18 ±1.36[ab]	63.63 ±1.99[ab]	54.52 ±1.19[b]
Vitamin C, mg	169.27 ±1.04[a]	217.53 ±1.49[a]	159.48 ±1.57[a]	195.74 ±1.47[a]	108.79 ±2.02[a]
% of RDA	208.79 ±2.9[ab]	280.14 ±2.08[a]	188.33 ±2.96[ab]	235.78 ±1.43[ab]	131.22 ±2.08[b]

The values in the same row with different superscript letters are significantly different ($p \leq 0.05$)

Also, vitamin E was deficient in all groups not reaching the RDA which is 15 mg/day with the highest intake in normal group 7.86 mg/day and lowest records markedly deteriorated in the compensated cardiac group 4.87 mg/day and the decompensated cardiac group 5.56 mg/day, these data were statistically significant with p-value < 0.05 and the results were concordant with **(Adonis and Rohit, 2010)** who stated that consumption of foods rich in vitamin E has been associated with lower risk of coronary heart disease in middle-aged to older men and women.

Vitamin K, RDA should exceed 120 µg/day but again was deficient in all groups of our study with the least intake in the decompensated cardiac patients reaching 59.04 µg/day and this was statistically significant, our result were similar to that from the Prospect- EPIC cohort (16057 women; 480 coronary heart disease events), a 10 µg/day higher vitamin K_2 intake was associated with a 9% lower risk of coronary heart disease **(Gast et al., 2009)**. In the Rotterdam Study (4807 men and women; 233 coronary heart disease events), individuals in the highest tertile of vitamin K_2 intake had a 41% lower risk of incident coronary heart disease compared with those in the lowest tertile **(Geleijnse et al., 2004)**.

vitamin C was exceeding 90 mg/day RDA, these data were statistically significant with p-value < 0.05 and the results were concordant with **(Knekt et al., 2004)** found that people who took ≥700 mg/day of supplemental vitamin C had a 25% lower risk of coronary heart disease incidence than those who took no supplemental vitamin C. Also, vitamin C has anti-inflammatory effects and is associated with lower endothelial dysfunction in men with no history of cardiovascular disease.

Daily nutrient intake of minerals of participants:

Table (4) showed that the sodium intake in all groups exceeded the RDA which is 2300 mg/day with the highest levels in the normal group (4656 mg/day) and risk factor group (4298 mg/day) and showed statistical significance from lower levels in cardiac groups (compensated group 3169 mg/day and decompensated group 3133 mg/day with p-value < 0.05, these results shows the risky situation of the normal group who adopt away from home frequent meals that is known of its high sodium load making this group at high future risk of developing hypertension followed by cardiac disease, as for the results of high risk group also shows their noncompliance to medical treatment and healthy

nutrition advices. On the other hand, the lower levels of the cardiac groups could be explained by the adherence to medications including diuretics that help excretion of sodium as well as better nutritional habits in salt restriction.

Our results were similar to the data from the report by the National Academies of Sciences, Engineering, and Medicine (NASEM) concluded that sodium intake and cardiovascular disease show a linear association **(Oria et al., 2019)**.

China, where sodium consumption exceeds that of most countries (above 5 g/day), marked reductions in sodium intake were reported over time (from 6.7 g/day in 1991 to 4.8 g/day in 2009), mainly due to lowering of salt intake at the table or during cooking **(Trieu et al., 2016)**.

Table (4) showed that potassium daily intake didn't reach RDA which is 4700 mg/day in the study groups, inspite no statistical difference between the different groups, the lowest levels were recorded in the cardiac patient groups (compensated group intake 3662.2 mg/day while decompensated group 3425.3 mg/day) as well as the metabolic syndrome group 3587.4 mg/day.

Nancy et al., (2013) showed that increased potassium intake reduced systolic blood pressure by 3.49 mm Hg and diastolic blood pressure by 1.96 mm Hg in adults, an effect seen in people with hypertension but not in those without hypertension.

We noticed in our study (table 4), that inspite all study groups intake for phosphorous was exceeding the RDA which is 700mg/day, still the recorded intake was much more than the recommendation with at least 3-4 folds in the study groups reaching 2941.7 mg/day in the normal group and this result was statistically significant (p-value < 0.05).

Alonso et al., (2010) analysed the associations of diet phosphorus with blood pressure at the baseline visit and incidence of hypertension in 13,444 participants from the Atherosclerosis Risk in Communities and the Multi-Ethnic Study of Atherosclerosis cohorts. These investigators found that, at best there is no association of dietary phosphorus intake with hypertension, with a possible signal for a protective effect of higher phosphorus intake against developing hypertension.

Table 4. Daily Minerals intakes of participants according to heart disease status

Minerals	Normal individuals	Metabolic syndrome	Risk factor patients	Compensated cardiac patients	Decompensated cardiac patients
Sodium, mg	4656±1.43^{a}	2804.7±1.74^{b}	4298.4±1.07^{ab}	3169.4±1.14^{b}	3133.6±1.42^{b}
% of RDA	310.4±1.09^{a}	186.98±1.32^{b}	286.56±1.58^{ab}	211.3±1.94^{b}	208.91±1.36^{b}
Potassium, mg	4293.5±1.0^{a}	3587.4±1.03^{a}	4619.4±1.64^{a}	3662.2±1.09^{a}	3425.3±1.78^{a}
% of RDA	91.35±1.09^{a}	76.33±1.32^{a}	98.28±1.93^{a}	77.92±1.21^{a}	72.88±1.51^{a}
Calcium, mg	1952.4±2.19^{a}	1229.1±1.96^{b}	1768.2±1.15^{ab}	1561.8±1.05^{ab}	1363.5±1.03^{ab}
% of RDA	195.24±2.89^{a}	122.91±1.89^{b}	176.82±1.35^{ab}	156.18±1.86^{ab}	136.35±1.80^{ab}
Phosphorus, mg	2941.7±1.15^{a}	1984.6±1.65^{b}	2717.3±1.12^{ab}	2202.3±2.14^{ab}	2146.8±1.20^{ab}
% of RDA	420.25±1.22^{a}	283.52±1.52^{b}	388.18±1.89^{ab}	314.62±1.05^{ab}	306.68±1.43^{ab}
Zinc, mg	26.98±1.85^{a}	30.72±1.98^{a}	23.79±1.45^{a}	23.58±1.43^{a}	21.96±1.36^{a}
% of RDA	245.31±1.91^{a}	279.27±1.37^{a}	216.24±1.41^{a}	214.41±1.26^{a}	199.68±1.67^{a}

The values in the same row with different superscript letters are significantly different ($p \leq 0.05$)

Again, we noticed in our study (table 4), that in spite all study groups intake for zinc was exceeding the RDA which is 11mg/day, still the recorded intake was much more than the recommendation with at least 2-3 folds in the study groups reaching 30.72 mg/day in the metabolic syndrome group and at least 2 folds in other groups in spite of statistical difference between groups.

Abul Hasnat et al., (2018) conducted a study to investigate dietary zinc as predictors of incident cardiovascular disease (CVD) in a large longitudinal study of mid-age Australian women (aged 50–61 years). A positive association between dietary zinc intake and risk of CVD was observed. Compared to those with the lowest quintile of zinc (5.94 mg/day), those in the highest quintile (17.35 mg/day) had almost twice the odds of developing CVD.

In the current study, table (4) shows that in spite all study groups intake for zinc was exceeding the RDA which is 8-18 mg/day, still the recorded intake was much more than the recommendation with at least 2-3 folds in the study groups reaching 32.43 mg/day in the normal and 26.45 mg/day for the risk factor group and this data was statistically significant higher than rest of groups with p-value < 0.05.

General anthropometric and biochemical characteristics of participants according to heart disease status:

Data in table (5) there was significant statistical difference as regard the weight between the groups with the highest weight recorded in the metabolic syndrome group (102.24) and the lowest in the compensated cardiac group (77.74) with (p-value <0.05), this results explain the abnormal metabolic state and the future risk burden to which the participants in the metabolic syndrome group are exposed to and also explains the improved and stable condition of the compensated cardiac patients group.

As regard BMI, it was high in all groups > 25 and there was significant statistical difference between the groups with the highest BMI recorded in the metabolic syndrome group (35.85) and the lowest in the compensated cardiac group (28.36) with (p-value <0.05), this results also explain the abnormal metabolic state and the future risk burden to which the participants in the metabolic syndrome group are exposed to and also explains the improved and stable condition of the compensated cardiac patients group. When sub classification of BMI was observed, the obesity grade was highest in the risk factor group and decompensated cardiac group (41.56 & 39.89 respectively) and lowest in compensated cardiac group (33.29) which also explain the risky situation of the risk factor group and the current worse cardiac condition of the decompensated cardiac group and again support the explanation of the stability of the cardiac condition of the compensated cardiac group.

These results were supported and concordant with the prospective trial conducted by **(Claes et al., 2022)** that included patients with stable coronary heart disease with 3 to 5 years' follow- up on optimal secondary preventive treatment. BMI was measured at baseline and associations between BMI and cardiovascular outcomes were evaluated.

They concluded that patients with stable coronary heart disease showed a graded increase in cardio metabolic and inflammatory risk factors with increasing BMI category >25 kg/m2. All- cause and cardiovascular mortality were lowest at BMI of 25 to 35 kg/m^2. Underweight with BMI of <20 kg/m2 and very high BMI of $\geq$35 kg/m^2 were strong risk markers for poor prognosis.

The mean waist circumference (WC) exceeded the accepted limits (< 90cm in males and < 80 cm in females) in all groups and there was significant statistical difference between groups with the highest values in the metabolic syndrome group and the decompensated cardiac patients group (119.43, 117.19 cm respectively with p-value < 0.05), our results shows that all the study participants are at risks or adverse cardiac event whether remotely in the normal group or shortly in the other groups specially the metabolic syndrome, risk factor groups and decompensated cardiac group that all exceeded mean of 100 cm. A positive data that explains cardiac disease control is the mean of WC in compensated cardiac disease which was the lease of all groups almost as normal group recording 98.22 cm.

The results of **(Chen et al., 2020)** identified that lager WC was statistically associated with hypertension, diabetes, smoking, high cholesterol, and decreased physical activity, which were established risk factors of CVD.

Hip circumference (HC) also in the current study exceeded the normal value limits (94-105 cm for men and 97-108 cm for women), it followed the same pattern of the WC, there was significant statistical difference between groups with the highest values in the metabolic syndrome group and the decompensated cardiac patients group (118.29 & 115.31 cm respectively with p-value < 0.05), our results shows that all the study participants are at risks or adverse cardiac event whether remotely in the normal group or shortly in the other groups specially the metabolic syndrome, risk factor groups and decompensated cardiac group that all exceeded mean of 100 cm. A positive data that explains cardiac disease control is the means of HC in compensated cardiac disease which was the lease of all groups almost as normal group recording 101.09 cm.

This specific finding was totally opposite to the literature and different studies in this issue, **(Lanfer et al., 2014)** found that baseline hip circumferences was significantly and inversely associated with all-cause and cardiovascular disease specific mortality after adjustment for BMI, WC and other covariates, they documented the existence of a basal risk associated with small hip size.

Parker et al., (2009) investigated that excess adiposity is a general risk factor for CVD, for a given BMI and waist circumference, greater hip circumference appears to lessen the risk of CVD.

In our study Waist to Hip ratio (WHR) a marker of central obesity that is tied to cardiovascular risk was out of the normal range (<1) in metabolic syndrome group and decompensated cardiac patient group (1.02 cm). In a multicenter trial conducted by Yusef et al., (2005), it was found that although BMI values were directly related to risk of myocardial infarction, the relation disappeared after adjustment for waist-to-hip ratio and other risk factors. Increasing waist-to-hip ratio was also found to be associated with increasing risk of myocardial infarction, but, in contrast to BMI, the relation remained significant after adjustment for BMI and other risk factors and even among those regarded as being very lean or of normal weight (BMI < 25 kg/m2). Unlike that for BMI, this association was evident across all world regions.

In the current study Waist to Height Ratio (WHtR) also was out of normal range (Normal <0.5) in all study groups with the highest (WHtR) recorded in the metabolic syndrome group and decompensated cardiac patients group (0.71 & 0.69 respectively) and the lowest in the compensated cardiac group and normal group (0.6 & 0.58 respectively) with (p-value <0.05), this results also explain the worse situation of decompensated cardiac group and explains the abnormal metabolic state and the future risk burden to which the participants in the metabolic syndrome group are exposed to and also explains the improved and stable condition of the compensated cardiac patients group. Our results conform to findings from studies conducted by **(Shen et al., 2017)** observed that the seven ideal cardiovascular health metrics, body mass index (BMI), total cholesterol (TC), blood pressure (BP), and fasting blood glucose (FBG) were found to increase with an elevation of the mean WC and WHtR. Cardiovascular health is correlated negatively with the WC and WHtR, and a stronger correlation existed between the cardiovascular health and WHtR than WC.

Biochemical assays in table (5) showed that apart from normal group, none of the other study groups did achieve their recommended low density lipoprotein (LDL) serum level according to their cardiac risk, the compensated and decompensated cardiac groups mean LDL levels (102.27 & 92.89 mg/dl respectively) were far away from their current recommended target goal which is 55 mg/dl, the same was for the risk factor group mean LDL level (122.36 mg/dl) while the current recommended target goal was 70 mg/dl and finally the metabolic syndrome group mean LDL level was (110.86

mg/dl) and the current recommended target goal was 100 mg/dl set by the American Heart Association guidelines **(Grundy et al., 2019)**.

In this study we can notice that there was significant statistical difference between different groups (p-value < 0.05) with worst diabetes control in the decompensated group glycated hemoglobin (HbA1C) 7.36 g/dl which explains their deteriorated condition, on the other hand we find a tight blood sugar control in the compensated cardiac group with normalization in the HbA1C level (5.39 g/dl) which explains the stability and improvement in their condition. Still the metabolic syndrome group and risk factor group were in risky zone and still exposed to future risks of adverse cardiac events because of their non-optimum levels of HbA1C (5.9 & 6.46 g/dl respectively).

In a multi-center study by **(Sinning et al., 2021)** evaluated HbA1c in conjunction with classical cardiovascular risk factors (CVRFs) for association with cardiovascular mortality, cardiovascular disease (CVD) incidence, and overall mortality. HbA1c was independently associated with cardiovascular mortality, overall mortality and cardiovascular disease in the general European population, underlining the importance of HbA1c levels in the overall population.

In our study kidney function test were within normal values in all groups (serum creatinine 0.6-1.2 mg/dl, blood urea nitrogen BUN 8-23 mg/dl and serum uric acid 2-7 mg/dl) except for the decompensated cardiac patients group that was elevated (serum creatinine 1.40 mg/dl, blood urea nitrogen, BUN, 27.13 mg/dl, mean serum uric acid 7.01 mg/dl), this kidney disorder add burden on cardiac patients and explain their decompensation.

Our results were confirmed by **(Jankowski et al., 2021)** who stated that patients with chronic kidney disease (CKD) exhibit an elevated cardiovascular risk manifesting as coronary artery disease, heart failure, arrhythmias, and sudden cardiac death.

Homocysteine as laboratory biomarkers in table (5) shows significant statistical difference between all groups as regard serum level of homocysteine with highest level in the decompensated group exceeding the normal accepted value (Normal 5-15 micmol/L) reaching (19.69 micmol/L), next comes the compensated cardiac group and risk factor group also with elevated levels (18.13 & 16.18 micmol/L respectively). This result shows the expected adverse cardiac event to which the risk factor group is exposed and explains the current cardiac risk present in the cardiac patient groups.

These results are parallel to results of study conducted in Taiwan by **Shih et al., (2021)** showed correlation between homocysteine level and other cardio-metabolic risk factors while adjusting for age, he found that middle-aged and elderly people with increased homocysteine levels were associated with higher CVD risk.

This was explained by **(Paganelli et al., 2021)** who stated that homocysteine is associated with inflammation and atherosclerosis, and it is an independent risk factor for CVD, stroke and myocardial infarction. Homocysteine worsens CVD by increasing the production of H_2S, which decreases the expression of adenosine A_{2A} receptors on the surface of immune and cardiovascular cells to cause inflammation and ischemia, respectively.

Echocardiography information of participants according to heart disease status:

Table (6) shows that there was significant statistical difference (p-value <0.05) between the study groups as regard the Left Ventricle, LV dimensions with the decompensated cardiac group showing increased LV systolic and diastolc dimension exceeding normal values (LVIDd < 57 mm, LVISd < 40 mm), and recording high mean values (mean LVIDd 57.75 mm, LVISd 41.13 mm) explaining the deteriorated cardiac condition of this group. The rest of the study groups were within the normal values.

Table 5. General anthropometric and biochemical characteristics of participants according to heart disease status

Parameter	Normal individuals	Metabolic syndrome	Risk factor patients	Compensated cardiac patients	Decompensated cardiac patients
Age (year)	31.22 ±3.68[b]	53.7 ±6.55[a]	57.3 ±5.06[a]	52.64 ±4.17[a]	59.69 ±2.48[a]
Anthropometric Parameters					
Weight, kg	79.65 ± 5.74[b]	102.24 ±6.85[a]	92.67 ±9.14[ab]	77.74 ±3.86[b]	93.7 ±5.38[ab]
Height, cm	170.1 ±3.08[a]	169.86 ±6.85[a]	170.91 ±3.87[a]	164.64 ±1.29[a]	168.38 ±1.72[a]
BMI, kg/m^2	27.32 ±1.64[b]	35.85 ±1.69[a]	32.15 ±3.66[ab]	28.36 ±1.58[ab]	33.23 ±2.012[ab]
WC, cm	98.22 ±4.09[b]	119.43 ±2.97[a]	108.55 ±6.13[ab]	98.22 ±4.30[b]	117.19 ±3.79[a]
HC, cm	106.22 ±4.9[ab]	118.29 ±5.39[a]	110.73 ±5.61[ab]	101.09 ±3.72[b]	115.31 ±4.13[ab]
WHR, cm	0.95 ±0.05[a]	1.02 ±0.03[a]	0.98 ±0.015[a]	0.97 ±0.02[a]	1.02 ±0.02[a]
WHtR, cm	0.58 ±0.02[b]	0.71 ±0.02[a]	0.63 ±0.04[ab]	0.60 ±0.03[b]	0.69 ±0.03[a]
Laboratory data and biomarkers					
TC, mg/dl	171 ±1.96[ab]	192.14 ±1.03[a]	183.91 ±1.62[a]	169.27 ±1.27[ab]	151.31 ±1.98[b]
HDL, mg/dl	45.56 ±1.77[ab]	52 ±1.58[a]	43.91 ±1.96[ab]	48.09 ±1.99[ab]	41.63 ±1.71[b]
LDL, mg/dl	104.1 ±1.42[ab]	110.86 ±1.26[ab]	122.36 ±1.48[a]	102.27 ±1.85[ab]	92.89 ±1.87[b]
HBA1C, mg/dl	5.22 ±0.154[c]	5.9 ±0.36[bc]	6.46 ±0.43[b]	5.39 ±0.16[c]	7.36 ±0.36[a]
Creatinine, mg/dl	0.86 ±0.06[b]	1.09 ±0.098[ab]	1.097 ±0.07[ab]	0.98 ±0.07[b]	1.40 ±0.16[a]
BUN, mg/dl	15.56 ±0.98[a]	15.43 ±0.92[a]	16.88 ±1.55[a]	17 ±0.95[a]	27.13 ±0.88[a]
Uric acid, mg/dl	5.44 ±0.29[b]	5.21 ±0.42[b]	5.83 ±0.35[ab]	6.06 ±0.31[ab]	7.01 ±0.58[a]
Homocysteine, micmol/L	12.56 ±0.43[c]	14.48 ±0.59[bc]	16.18 ±0.81[b]	18.13 ±1.94[ab]	19.69 ±1.66[a]

The values in the same row with different superscript letters are significantly different ($p \leq 0.05$), BMI: Body Mass Index, WC: Waist Circumference, HC: Hip Circumference, WHR: Waist-to-Hip Ratio, WHtR: Waist-to-Height Ratio, TC: Total Cholesterol, LDL: Low Density Lipoprotein, HDL: High Density Lipoprotein, HBA1C: Glycated hemoglobin, BUN: blood urea nitrogen.

Left ventricle systolic function represented in this study by left ventricle ejection fraction (LVEF) was shown in table (6) to follow the same pattern of the LV dimensions as there was significant statistical difference between the study groups with the decompensated cardiac group showing decreased LVEF below normal values (LVEF > 55%) and recording low mean values (mean LVEF 54.38 %) explaining the deteriorated cardiac condition of this group. The rest of the study groups were within the normal values.

Data from Studies of Left Ventricular Dysfunction (SOLVD) registry have shown that increased LV end- systolic diameter was associated with cardiovascular death **(Quinones et al., 2000)**. Similarly, analysis from the MADIT- CRT trial showed a graded reduction in risk of death or heart failure with decreasing LV diastolic volumes **(Solomon et al., 2010)**. Some studies in selected populations have suggested that LV diameter could be useful in SCD risk assessment **(Watanabe et al., 2005)**.

Left ventricle diastolic function represented in this study by left ventricle ejection fraction (LVEF) was shown in table (6) to be impaired in all groups sparing only the normal group with the highest group suffering from diastolic dysfunction (DD) the risk factor group (100% of the group participants suffered DD) next comes the decompensated cardiac group (87.5% suffered DD), next comes the metabolic syndrome group (71.42% suffered DD) and finally the compensated cardiac group (45.45% suffered DD), this result is rich in much information about the different cardiac condition of the study groups, since the diastolic cardiac function is one of the most sensitive cardiac parameter to any abnormal cardiac stress, it is affected at early stages faraway before development of cardiac disease, thus to find that 71.42% of the metabolic syndrome group participant - who don't suffer any cardiac problems - to have DD this speaks about documented cardiac structural abnormality the starts early before development of cardiac diseases.

In our study Left Ventricle, LV wall thickness represented by interventricular septum thickness at end diastole (IVSd) was found to exceed normal values (9-11 mm) in two of study groups, the risk factor group with mean value of 11.55 mm and the decompensated cardiac group with mean value of 11.5 mm this shows the high future risk to which the risk factor group participants are exposed to and explains the current suffering and instability of the cardiac condition of the decompensated group. On the other hand, the normal mean value of the compensated cardiac group 9.79 mm supports their controlled and stable cardiac condition.

Our results were supported and confirmed by **Bornstein et al., (2024)** reported that the presence of LVH forecasts an increased risk of cardiovascular morbidity and mortality, even after adjustment for major cardiovascular risk factors such as age, smoking, obesity dyslipidemia, blood pressure, and diabetes. This means that LVH is an independent risk factor for cardiovascular disease.

In our results, LV Segmental Wall Motion Abnormality (SWMA) was present only in cardiac patient's groups, 37.5% of decompensated cardiac patients and 9.1% of compensated cardiac patients, these results again show the high risk of adverse cardiac events to which the decompensated cardiac patients are exposed to and the more stable clinical condition of the compensated cardiac group.

The presence of SWMA abnormalities has been demonstrated to be an independent predictor of cardiovascular events in groups of patients with myocardial infarction (MI) **(Carluccio et al., 2000)**.

In our study the Right Ventricle Systolic Pressure, (RVSP) which is considered a marker for pulmonary hypertension, exceeded the normal value which is 33 mmHg in three of our study groups. First, the risk factor group with mean value 34 mmHg, next the compensated cardiac group with mean value 34.55 mmHg and finally with the highest mean value the decompensated cardiac group 41.0 mmHg, these results show the exerted cardia risk on these three groups specially the decompensated groups carrying the worst values and worst prognosis.

Our results were confirmed by **Kotrri et al., (2023)** who reported that pulmonary hypertension is common among patients with heart failure (HF). Right ventricular systolic pressure (RVSP) is frequently used to assess its presence and severity.

In our results Right Ventricle Chambers, RVC enlargement, which is also considered as marker that represents pulmonary hypertension, it was found to follow the same pattern of RVSP being present only in the same previously described three groups, it was present in 18.18% of risk factor group, in 27.27% of compensated cardiac group and in 12.5% of the decompensated cardiac group.

Table 6. Echocardiographic information of participants according to heart disease status

Measure		Normal individuals	Metabolic syndrome	Risk factor patients	Compensated cardiac patients	Decompensated cardiac patients
LVIDd, mm		49.89 ±1.76^{b}	50.57 ±1.45^{b}	50.19 ±1.29^{b}	51.46 ±1.61^{ab}	57.75 ±2.76^{a}
LVISd, mm		31 ±1.69^{b}	32.86 ±1.71^{b}	31.18 ±1.26^{b}	33.27 ±1.56^{b}	41.13 ±1.49^{a}
LVEF, percent		64.78 ±1.19^{a}	61.86 ±1.84^{ab}	66.27 ±1.5^{a}	63.18 ±1.58^{ab}	54.38 ±1.98^{b}
IVSd		8.83 ±0.29^{c}	10.21 ±0.1^{b}	11.55 ±0.24^{a}	9.79 ±0.46^{b}	11.5 ±0.21^{a}
RVSP		23.11 ±0.68^{b}	25.86 ±1.92^{b}	34±1.25^{a}	34.55 ±1.34^{a}	41.0 ±1.33^{a}
LAAP	**Increased**	0	1 (14.28)	6 (54.54)	9 (81.81)	16 (100)
	Normal	9 (100)	6 (85.71)	5 (45.45)	2 (18.18)	0
RSC	**Increased**	0	0	2 (18.18)	3 (27.27)	2 (12.5)
	Normal	9 (100)	7 (100)	9 (81.81)	8 (72.72)	14 (87.5)
MR		0	0	1 (9.1)	4 (36.36)	6 (37.5)
SWMA		0	0	0	1 (9.1)	6 (37.5)
LVDD		0	5 (71.42)	11 (100)	5 (45.45)	14 (87.5)
AR		0	0	0	1 (9.1)	3 (18.75)
MS		0	0	0	6 (54.54)	3 (18.75)
AS		0	0	0	1 (9.1)	2 (12.5)

The values in the same raw with different superscripted letters are significantly different ($p \leq 0.05$); LVIDd: left ventricular internal dimension at end diastole; LVISd: left ventricular internal dimension at end systole; LVEF: left ventricular ejection fraction; IVSd: interventricular septum thickness at end diastole; SWMA: segmental wall motion abnormality; LVDD: Left Ventricular Diastolic Dysfunction; LA AP: Left Atrium Antero-Posterior Dimension; MR: mitral regurgitation; RVSP: right ventricle systolic pressure; RSC: Right Side Chambers; AR: aortic valve regurgitation; MS: mitral valve stenosis; AS: aortic valve stenosis.

In our study, the Left Atrium LA size which was represented by LA anteroposterior diameter measurement was found exceed the upper normal limit which is 40 mm in all (100%) of decompensated cardiac group, 81.81% of compensated cardiac patients and in 54.54% of risk factor group, the result shows the high cardiac risk these three groups are exposed to.

Many studies have shown the clinical significance of an increase in left atrial (LA) dimension, to include the risk of atrial fibrillation, thromboembolism, stroke and death **(Kizer et al., 2006)**. The standard measurement for LA size is the anteroposterior dimension of the left atrium in M-mode or two-dimensional echocardiography, as characterized by the **American Society of Echocardiography, (2005)**, the traditional LA dimension (LAD) remains the most widespread method of measuring LA size being simple and extensively investigated. Even the most recent requirements of the Intersocietal Commision on the Accreditation of Echocardiography Laboratories list the LAD as one of the seven critical measures required on every echo exam **(Katanick, 1998)**.

While about Cardiac valves in our study table (6) shows that mitral regurgitation (MR), aortic regurgitation (AR) and aortic stenosis (AS) mainly affected the decompensated group (37.5%, 18.75% and 12.5% respectively) more than the compensated cardiac group (36.36%, 9.1% and 9.1% respectively), almost sparing the rest three groups. This result shows the added risk implied on the decompensated cardiac group increasing their suffering and instability.

Mitral stenosis mainly affected the compensated cardiac group (54.54%) more than the decompensated group (18.75%) sparing the rest of the group. This result shows that patients suffering from mitral stenosis, if obedient not only to medical treatment, but also to proper dietary and lifestyle

management including weight reduction, this can move them from instability condition to more stable and controlled cardiac condition and protect them from adverse cardiac events in the future.

CONCLUSION

Based on the data, we could conclude that the prevalence of cardiovascular disease is a severe problem of public health significance. Therefore, increasing awareness of the high prevalence of cardiovascular risk factors among the public is crucial. In addition, there is an urgent need for nutrition education programs to increase awareness regarding healthy diets and diet-related chronic diseases. This should be combined with encouragement of healthy lifestyle patterns, including increasing physical activity to enhance the prevention of CVD and associated risk factors.

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