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Neck Circumference: A Possible Predictor of Metabolic Disorders in the Hospital Setting

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ABSTRACT

Introduction: Malnutrition is considered to be a severe complication in hospitalized patients, which increases the length of hospital stay, treatment costs, and mortality. The present study aimed to evaluate neck circumference as a possible predictor of metabolic disorders in the hospital settings.

Methods: This study was conducted on 300 hospitalized patients selected from the internal disease ward of Imam Reza Hospital in Tabriz, Iran. Data were recorded on their demographic characteristics, medical history, medication use, and anthropometric and biochemical parameters. Dietary supplementation use, nutritional support, and physical activity (PA) were also measured using the subjective global assessment tool, and neck circumference (NC) was measured by the researcher. Data analysis was performed in SPSS version 16.0.

Results: In total, 61.8% of the male and 65.9% of the female patients had an NC of equal to or higher than normal. Chi-square was applied to assess the categorical variables, and one-way ANOVA was used for the continuous variables, indicating significant correlations between the NC and gender, body mass index, marital status, occupation status, PA, current nutritional status, and medical history such as diabetes mellitus (DM), hypertension (HTN), and renal disorders, as well as the use of some medications (P<0.05). Furthermore, significant correlations were denoted between the NC and levels of albumin (P=0.025), *mean corpuscular volume* (P=0.001), and total bilirubin (P=0.034). Systolic blood pressure was also significantly correlated with the NC (P=0.033).

Conclusion: NC represents a relatively new anthropometric assessment, which is rarely used in clinical practice, while it is easy to perform and has excellent reproducibility. Our findings indicated that NC, DM, and HTN were correlated. Further studies are suggested to establish accurate associations between NC and metabolic disorders and confirm their correlations with biochemical factors.

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Introduction

Malnutrition is a severe complication in hospitalized patients, which adversely affects the treatment process by causing weight loss, impaired pulmonary and cardiac function, bedsores, impaired wound healing, thromboembolism, and impaired renal function (1-6). Malnutrition also increases the length of hospital stay, treatment costs, and mortality (7-10).

The assessment of nutritional status is considered to be a reliable indicator of health. In general, nutritional assessment in hospitalized patients is possible via anthropometric, biochemical, clinical, and dietary evaluations. Neck circumference (NC) has recently attracted the attention of researchers owing to its efficiency in determining cardiometabolic risk factors and numerous chronic diseases, such as cardiovascular disorders, metabolic disorders, and chronic kidney disease. NC also represents the upper body subcutaneous adipose tissue and predicts the incidence of premature deaths in community-based populations (11-17).

Some studies have investigated the correlation between NC and metabolic disorders. For instance, Laura Boemeke et al. examined 82 patients and measured their height, weight, NC indices, abdominal circumference, laboratory tests, and liver biopsy, observing a significant association between insulin resistance and Non-alcoholic fatty liver disease (NAFLD) and concluding that NC could be used in the screening of insulin resistance in NAFLD patients (18). In another research, Albassam R. S. et al. assessed 623 women aged 18-70 years

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who were recruited from various primary care centers in Riyadh (Saudi Arabia) and measured their waist circumference (WC), NC, body mass index (BMI), blood pressure, and metabolic and serological markers. According to the findings, NC was independently and significantly associated with cardiometabolic risk factors in the participants (19). In a cross-sectional study conducted by Lin S. et al. on 1,473 subjects aged more than 50 years, NC was reported to be associated with metabolic syndrome (20).

According to the literature, NC may be reliable maker to evaluate various metabolic disorders. Due to the lack of similar research in this regard, the present study aimed to investigate the correlation of NC with metabolic disorders in the hospital settings in Tabriz, Iran.

Materials and Methods

Subjects

This cross-sectional study was conducted on the patients admitted to the internal disease ward of Imam Reza Hospital in Tabriz, Iran. The patients were admitted during March-June 2019. The inclusion criteria were hospitalized patients aged more than 18 years and diagnosed with hypertension (HTN), diabetes mellitus (DM), cardiovascular diseases, hyperlipidemia, gastric intestinal disease, renal diseases, cardiac diseases, stroke, edema, and pneumonia. The patients aged less than 18 years, those diagnosed with thyroid diseases, upper respiratory tract diseases, and allergies that temporarily affected the NC, and the patients with head and neck diseases and cancers were excluded from the study.

Data were collected on the demographic characteristics, past and current medical history, and medication use from the hospital records and enquiry of the patients. The obtained data included the history of HTN, DM, cardiac diseases, stroke, edema, pneumonia, alcohol consumption/smoking habits, and vital signs.

The study protocol was approved by the Ethics Committee of Tabriz University of Medical Sciences (code: IR.TBZMED.REC.1398.467), and written informed consent was obtained from the patients prior to enrollment.

Anthropometric, Biochemical, and Nutritional Assessments

Anthropometric parameters (weight and height) were obtained from the medical records of the patients. NC was measured under the level of the thyroid cartilage, perpendicular to the vertical axis of the neck, using a measurement tape and recorded in centimeters. Furthermore, data on the dietary intake of the patients were collected using the subjective global assessment tool, including dietary supplementation, nutritional support, and physical activity (PA). Biochemical parameters included complete blood cell count, liver functional tests, aspartate aminotransferase (AST), alanine amino transferees (ALT), alkaline phosphatase, lipase, and amylase.

Sample Size

The primary data for the calculation of the sample size were obtained from the study by Laura De La Higuera et al. (21) considering 95% confidence level, 80% test power, and 5% error using the Cochran formula.

$$n = \frac{\mathrm{Nz2pq}}{\mathrm{Nd2 + z2pq}}$$

The final sample size was calculated to be 300 participants.

Statistical Analysis

Data analysis was performed in SPSS version 16.0 (SPSS Inc., IL., Chicago, USA), and the correlations between the qualitative variables were assessed using Chi-square. After evaluating the normality of the data using one-sample Kolmogorov-Smirnov test, the paired comparison of the study groups was performed using independent t-test and the Mann-Whitney U test for the normal and non-normal variables, respectively. In addition, the comparison of three groups was carried out using the Kruskal-Wallis test and analysis of variance (ANOVA) for the non-normal and normal variables, respectively.

Results

Demographic Assessment

Among the male patients, 84 cases (61.8%) had an NC of equal to or higher than 35.5 centimeters (overweight/obesity cutoff for men), and among the females, 110 patients (65.9%) had an NC of equal to or higher than 32 centimeters (overweight/obesity cutoff for women) (22).

To evaluate the effects of demographic factors on the NC, we used Chi-square for the categorical variables and one-way ANOVA for the continuous variables (Table 1). The obtained results indicated significant correlations between the NC and gender, BMI, marital status, occupation status, PA, current nutritional status, and medical history such as DM, HTN, and renal diseases. Furthermore, the consumption of anti-hypertensive and anti-diabetic medications, statins, proton-pump inhibitors, anticoagulants, and supplementations was significantly correlated with NC.

Biochemical Assessment

To assess the trend of changes in the biochemical factors with NC, we used one-way ANOVA for the normal data and Kruskal- Wallis H for the non-normal data (Table 2). According to the findings, NC and albumin, *mean corpuscular volume*, and mean cell hemoglobin levels were significantly correlated. Furthermore, systolic blood pressure (SBP) was significantly correlated with NC.

Table 1. Demographic, lifestyle, anthropometric and clinical characteristics among tertiles of neck circumference value.

Variables(number)	1st tertile	2nd tertile	3rd tertile	P
Gender(303)				
Male(136)	35(32.1%)	35(36.1%)	66(68.0%)	**<0.001**
Female(167)	74(67.9%)	62(63.9%)	31(32.0%)	
Age(302)	57.76±18.22	56.16±16.78	60.78±14.22	**0.144**
BMI (303)				
Underweight (4)	3(2.8%)	1(1.0%)	0(0.0%)	
Normal (127)	76(69.7%)	31(32.0%)	20(20.6%)	**<0.001**
Overweight (121)	26(23.9%)	48(49.5%)	47(48.5%)	
Obese(51)	4(3.7%)	17(17.5%)	30(30.9%)	
Addiction(303)				
Cigarette(36)	14(12.8%)	7(7.2%)	15(15.5%)	
Alcohol (4)	2(1.8%)	1(1.0%)	1(1.0%)	**0.452**
Both (4)	2(1.8%)	1(1.0%)	1(1.0%)	
None (239)	93(85.3%)	89(91.8%)	81(83.5%)	
Marital status (303)				
Single (24)	11(10.1%)	11(11.3%)	2(2.1%)	**0.033**
Married (279)	98(89.9%)	86(88.7%)	95(97.9%)	
Family size (303)				
0-2(73)	28(25.7%)	18(18.6%)	27(27.8%)	
3-4(157)	59(54.1%)	52(53.6%)	46(47.4%)	**0.438**
≥5 (72)	21(19.3%)	27(27.8%)	24(24.7%)	
Num. of children (303)				
0-2(115)	40(36.7%)	39(40.2%)	36(37.1%)	
3-4(83)	24(22.0%)	30(30.9%)	29(29.9%)	**0.354**
≥5 (105)	45(41.3%)	28(28.9%)	32(33.0%)	
Occupation (303)				
No job (175)	75(68.8%)	63(64.9%)	37(38.1%)	
Employee (16)	2(1.8%)	4(4.1%)	10(10.3%)	**<0.001**
Self-employment (85)	26(23.9%)	21(21.6%)	38(39.2%)	
Retired(27)	6(5.5%)	9(9.3%)	12(12.4%)	
Education (303)				
Illiterate (119)	48(44.0%)	36(37.1%)	35(36.1%)	
Diploma or under diploma (158)	54(49.5%)	54(55.7%)	50(51.5%)	**0.433**
University degrees(26)	7(6.4%)	7(7.2%)	12(12.4%)	
Income (303)				
<1million (76)	35(32.1%)	20(20.6%)	21(21.6%)	
1-3million (211)	70(64.2%)	74(76.3%)	67(69.1%)	**0.066**
>3million(16)	4(3.7%)	3(3.1%)	9(9.3%)	
Physical activity (303)				
Low (180)	53(48.6%)	57(58.8%)	70(72.2%)	**0.003**
High(123)	56(51.4%)	40(41.2%)	27(27.8%)	
Current Nutrition (303)				
PN (2)	1(0.9%)	1(1.0%)	0(0.0%)	
EN (2)	1(0.9%)	1(1.0%)	0(0.0%)	**0.004**
NPO (56)	32(29.4%)	17(17.5%)	7(7.2%)	
Oral (243)	75(68.8%)	78(80.4%)	90(92.8%)	
Sleep duration (302)	7.06±1.69	6.85±1.54	6.86±1.37	**0.515**

Note: PN, Parentral Nutrition; EN, Entral Nutrition; NPO,Nil Per Os;

1st tertile: NC<32 cm; 2nd tertile: 32<NC<37; 3rd tertile: NC>37cm.

*P-value is calculated by Chi-square and p<0.05 was considered as a significance level.

Table 2. Comparison of history of disease and drug use among tertiles of neck circumference value.

History of Diseases				
Variables (number =303)	**1st tertile of NC**	**2nd tertile of NC**	**3rd tertile of Nc**	**P**
DM YES(92)	20(18.3%)	27(27.8)	45(46.4%)	**<0.001**
CVD YES(40)	11(10.1%)	12(12.4%)	17(17.5%)	**0.278**
HTN YES(151)	42(38.5%)	50(51.5%)	59(60.8%)	**0.006**
KD YES(96)	14(12.8%)	33(34.0%)	49(50.5%)	**<0.001**
HLP YES(30)	10(9.2%)	11(11.3%)	9(9.3%)	**0.867**
GI-Disease YES(26)	10(9.2%)	12(12.4%)	4(4.1%)	**0.118**
Drug Use				
Variables (number)	**1st tertile of NC**	**2nd tertile of NC**	**3rd tertile of Nc**	**P**
phosphate binders (301)				**0.111**
NO (210)	68(63.0%)	74(77.1%)	68(70.1%)	
History (9)	2(1.9%)	2(2.1%)	5(5.2%)	
Current (19)	11(10.2%)	2(2.1%)	6(6.2%)	
History and current(63)	27(25.0%)	18(18.8%)	18(18.6%)	
AntiHTN(302)				**<0.001**
NO (153)	71(65.1%)	44(45.8%)	38(39.2%)	
History (49)	22(20.2%)	18(18.8%)	9(9.3%)	
Current (26)	3(2.8%)	12(12.5%)	11(11.3%)	
History and current(74)	13(11.9%)	22(22.9%)	39(40.2%)	
AntiDM(302)				**<0.001**
NO (228)	93(85.3%)	69(71.9%)	66(68.0%)	
History (28)	11(10.1%)	10(10.4%)	7(7.2%)	
Current (6)	2(1.8%)	4(4.2%)	0(0.0%)	
History and current(40)	3(2.8%)	13(13.5%)	24(24.7%)	
Anti HLP (302)				**0.001**
NO (247)	98(89.9%)	78(81.3%)	71(73.2%)	
History (16)	6(5.5%)	8(8.3%)	2(2.1%)	
Current (19)	1(0.9%)	5(5.2%)	13(13.4%)	
History and current(20)	4(3.7%)	5(5.2%)	11(11.3%)	
PP inhibitor (302)				**0.011**
NO (171)	54(49.5%)	54(56.3%)	63(64.9%)	
History (36)	21(19.3%)	11(11.5%)	4(4.1%)	
Current (73)	28(25.7%)	26(27.1%)	19(19.6%)	
History and current(22)	6(5.5%)	5(5.2%)	11(11.3%)	
Anti-Coagulant (302)				**0.002**
NO (191)	76(69.7%)	60(62.5%)	55(56.7%)	
History (28)	16(14.7%)	7(7.3%)	5(5.2%)	
Current (60)	16(14.7%)	20(20.8%)	24(24.7%)	
History and current(23)	1(0.9%)	9(9.4%)	13(13.4%)	
Supplements(301)				**<0.001**
NO (148)	84(77.1%)	41(42.7%)	23(24.0%)	
History (15)	6(5.5%)	7(7.3%)	2(2.1%)	
Current (39)	4(3.7%)	22(22.9%)	13(13.5%)	
History and current(99)	15(13.8%)	26(27.1%)	58(60.4%)	

Note: DM, Diabet Mellitus; CVD, Cardio Vascular Diseases; HTN, Hyper Tension; KD, Kidney Disease; HLP, Hyper Lipid Profile; GI-Diseases, Gastro Intestinal-Diseases.

1st tertile: NC<32 cm; 2nd tertile: 32<NC<37; 3rd tertile: NC>37cm.

*P-value is calculated by Chi-square and p<0.05 was considered as a significancy level.

Table 3. Biochemical and vital signs parameters among neck circumference tertiles.

Variable	1st tertile of NC	2nd tertile of NC	3rd tertile of NC	Total	P value
Ferritin (ng/ml)	292.66 ± 215.77	300.54 ± 305.99	296.40 ± 184.60	296.78 ± 219.47	**0.997**
TIBC (µg/dl)	288.83 ± 79.79	319.14 ± 60.82	347.78 ± 43.55	327.25 ± 60.10	**0.120**
FBS (mg/dl)	119.70 ± 71.60	115.89 ± 47.21	137.50 ± 72.21	126.93 ± 65.40	**0.333**
BS (mg/dl)	134.19 ± 70.90	181.29 ± 136.87	157.21 ± 108.07	156.27 ± 107.27	**0.291**
Cholesterol (mg/dl)	148.07 ± 46.17	191.06 ± 78.23	161.46 ± 41.08	164.75 ± 52.13	**0.064**
TG (mg/dl)	124.31 ± 50.28	151.16 ± 93.87	180.44 ± 86.00	162.85 ± 84.31	**0.055**

LDL-C (mg/dl)	95.83 ± 29.08	116.22 ± 65.02	104.50 ± 31.87	106.02 ± 41.64	**0.643**
HDL-C (mg/dl)	47.14 ± 15.91	36.77 ± 9.94	34.76 ± 9.80	37.59 ± 11.83	**0.050**
CRP (mg/L)	27.80 ± 27.64	38.20 ± 15.81	24.03 ± 13.85	27.49 ± 18.04	**0.321**
Alb (mg/dl)	3.72 ± 0.79	3.56 ± 0.92	14.14 ± 0.88	3.83 ± 0.85	**0.025***
PR (bpm)	81.52 ± 9.67	81.85 ± 9.20	80.60 ± 7.95	81.32 ± 8.97	**0.641**
RR (bpm)	17.30 ± 2.17	17.55 ± 2.20	17.63 ± 2.02	17.49 ± 2.13	**0.561**
WBC (1000/mm²)	8.07 ± 4.06	8.14 ± 3.61	8.68 ± 3.65	8.29 ± 3.79	**0.489**
RBC (1000/mm²)	3.94 ± 0 .76	3.81 ± 0.61	3.80 ± 0.52	3.89 ± 5.03	**0.619**
Hb (gm/dl)	11.30 ± 2.2	10.85 ± 2.2	11.50 ± 1.67	11.30 ± 2.03	**0.142**
Hct (%)	33.55 ± 4.7	32.75 ± 6.8	34.20 ± 4.27	33.60 ± 5.03	**0.229**
MCV (fL)	85.00 ± 5.00	85.00 ± 4.66	86.00 ± 5.00	85.00 ± 5.00	**0.001***
MCH (Pgm)	29.00 ± 1.66	28.00 ± 3	30.00 ± 2.00	29.00 ± 2.00	**0.009***
MCHC (%)	34.00 ± 1.00	34.00 ± 1.70	34.00 ± 2.00	34.00 ± 1.00	**0.563**
Plt (1000/mm²)	206.00 ± 86.00	211.50 ± 73.00	209.00 ± 62.66	210.00 ± 67.67	**0.706**
BT (ºC)	13.05 ± 2.00	37.00 ± 1.20	37.00 ± 0.00	37.00 ± 0.2	**0.014***
ALT	20.00 ± 47.00	19.00 ± 14.66	17.00 ± 8.66	19.00 ± 17.00	**0.212**
ALP	297.00 ± 218.33	323.50 ± 125.66	315.50 ± 206	309.50 ± 175.00	**0.968**
Total Billi	1.05 ± 0.9	0.9 ± 1.36	0.50 ± 0.5	0.90 ± 0.93	**0.034***
Amylase	47.50 ± 34.34	56.00 ± 55.66	74.00 ± 26.00	55.00 ± 38.67	**0.500**
Lipase	46.00 ± 21.34	44.50 ± 28.66	48.00 ± 18.00	46.50 ± 20.67	**0.808**
SBP (mmHg)	1.56 ± 0.94	1.95 ± 1.15	1.82 ± 1.17	1.76 ± 1.09	**0.033***
DBP (mmHg)	1.17 ± 0.46	1.24 ± 0.51	1.21 ± 0.40	1.20 ± 0.46	**0.563**

*Statically significant

Note: WBC, White Blood Cells; TIBC, Total Iron Binding Capacity; TG, Triglyceride; LDL-C, Low Density Lipoprotein-Cholesterol; HDL-C, High Density Lipoprotein-Cholesterol; CRP, C-Reactive Protein; Alb, Albumin; SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure; PR, Pulse Rate; RR, Respiratory Rate; RBC, Red Blood Cells; Hb, Hemoglobin; Hct, Hematocrit; MCV, Mean Corpuscular volume; MCH, Mean Corpuscular Hemoglobin; MCHC, Mean Corpuscular Hemoglobin Concentration; Plt, Platelets; INR, International Normalized Ratio; PT, Prothrombin Time; PTT, Partial Thromboplastin Time;BT, Body Temprature.

1st tertile: NC<32 cm; 2nd tertile: 32<NC<37; 3rd tertile: NC>37cm

Discussion

This cross-sectional study was conducted during March-June 2019 on the patients admitted to Imam Reza Hospital in Tabriz, (Iran), and significant associations were observed between gender, BMI, PA, and medical history with NC. In addition, men had a higher NC compared to the women, and the subjects with first-grade obesity had higher NC compared to those with normal weight. This finding is consistent with the study by Laura Boemekes, which indicated that the patients with a higher NC also had higher abdominal circumference and BMI compared to the patients with a normal NC (18). In addition, our findings are consistent with the study by Wan et al., which demonstrated that the visceral adiposity index was associated with the prevalence of diabetic kidney disease and cardiovascular diseases, while also uniquely correlated with the prevalence of common carotid artery plaque in diabetic adults (23). Therefore, it could be inferred that the effects of a large NC on the kidneys may start in the early stages of diabetes. Lipolytic activity has been considered to be a mechanism that may interfere with the case. To justify, it could be stated that free fatty acids (FFAs) are released from the upper body subcutaneous fat and cause oxidative stress and vascular injury (24). In the current research, increased NC was positively correlated with low PA, DM, HTN, and renal diseases, which is in line with the findings of a 10-year study (25) conducted on 2,623 patients. The mentioned research indicated that the male patients with a higher NC were at the higher risk of type II DM. In another study, Khalangot et al. also reported that NC is a new risk factor for DM and is independent of other indicators of adipose tissue distribution and thyroid gland volume (26).

In this regard, Li et al. (27) investigated the correlation of NC with the BMI of ≥18.5-<25 kg/m^2 in 2,668 NAFLD patients with the mean age of 50.07±14.09 years, reporting correlations between NC, hip circumference, WC, BMI, and diastolic and systolic blood pressure in both genders. Moreover, NC was observed to be an independent indicator of NAFLD in eutrophic men (BMI≥18.5-<25 kg/m^2), while no such association was observed in women due to the fact that female hormones may act as protective factors for the development of NAFLD, and the number of female smokers was also lower than the male smokers in the mentioned study.

Cigarettes cause oxidative stress, which plays a key role in the pathophysiology of NAFLD. However, the mechanism for the association between NAFLD and smoking remains unclear.
According to the literature, NC is positively correlated with some cardiovascular risk factors, such as high blood glucose and triglyceride levels, while negatively correlated with changes in high-density lipoprotein (12). In the current research, no significant correlation was denoted between NC and lipid profile. According to the biochemical results of our patients, NC was significantly and positively correlated with AST and albumin levels, while negatively correlated with total bilirubin levels. This is consistent with the studies indicating that NC is a potential predictor of fatty liver disease and cardiometabolic risk factors (12, 27, 28).
A study in this regard was conducted to evaluate the association of NAFLD and NC (29) in 2,761 Chinese patients, and the results demonstrated that patients with NAFLD and altered glutamic-pyruvic transaminase (GPT) had the mean NC of 38.94±2.62 centimeters, while the patients without altered GPT had the mean NC of 37.21±3.06 centimeters. In the mentioned research, the NC values were significantly higher compared to the subjects with other metabolic disorders, such as HTN, dyslipidemia, pre-diabetes, DM, overweight and obesity, abdominal obesity, gout, and hyperuricemia.
The findings of the current research demonstrated a significant correlation between NC and SBP, which is in line with the study by Zaciragic A. et al. Furthermore, Moradi et al. reported that DBP and SBP in adults are significantly and directly correlated with NC, and NC could be used more effectively than WC for the assessment of metabolic health as it is also capable of predicting cardiovascular risk factors and excess fat (30). However, the precise mechanism involved in the association of NC and HTN has not been entirely identified. Most of the studies in this regard have been focused on releasing larger amounts of systemic FFAs by the upper body subcutaneous fat than the visceral fat, which is the main source of abnormal FFA metabolism (31-35).

Strengths and Limitations

The strength of our study was its novelty in assessing the associations of NC with demographic and biochemistry factors in hospitalized patients. One of the limitations of the present study was the cross-sectional design, which could not reveal the cause-and-effect correlations. In addition, the specific geographical area of the study might have affected its external validity. Despite the confounding nature of variables such as alcohol consumption, viral hepatitis, and fasting insulin levels, we could not exclude the confounding bias caused by these factors.

Conclusion

According to the results, there were significant correlations between NC and DM, hypertension, altered AST, albumin, and bilirubin levels. Further investigations are required to determine whether the measurements could complement or replace routine anthropometric measurements of BMI and WC in the assessment of nutritional status.

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Conflicts of interest

None declared.

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