Neck Circumference and Cardio-Metabolic Risk in Normal Exercise Capacity Perimenopausal/Menopausal Women

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Background: *Screening tools that include additional biomarkers may yield better predictive value for hypertension, impaired glucose tolerance, and other cardiovascular disease (CVD) risk factors and help identify those individuals who may benefit from more in-depth assessment. Neck circumference (NC) is a simple screening measure for identifying cardio-metabolic risk in perimenopausal and menopausal women.*
Objective: *To determine whether a single measure of NC might be used to identify cardio-metabolic risk. NC for comparing with existing traditional anthropometric parameters such as body mass index (BMI) and waist-hip ratio (WHR).*
Material and Method: *The cross-sectional study with 76 perimenopausal and menopausal participants aged 40 to 70 years were recruited from Suranaree University of Technology Hospital between September 2015 and February 2016. Anthropometric indices, biochemical laboratory, and clinical parameters were measured. The NC of larger than 35 cm parameters was the cut-off in normal NC in women. All participants did exercise stress test.*
Results: *Seventy-six perimenopausal/menopausal women were included in this study. The NC was positively correlated with weight, BMI, and waist circumference (WC) ($r = 0.72$, 0.72 and 0.65 respectively, all $p<0.01$) and negatively correlated with high-density lipoprotein cholesterol (HDL-C) ($r = -0.44$, $p<0.01$). Other laboratory parameters such as fasting blood sugar (FBS) ($r = 0.23$, $p = 0.04$) and triglyceride (TG) ($r = 0.31$, $p<0.01$) were also positively correlated.*
Conclusion: *NC measurement is a simple and a time saving screening measure that can be used to identify cardio-metabolic risk associated with simple anthropometric parameters such as BMI, WC, FBS, TG, and HDL-C. Participants with NC equal or greater than 35 cm were correlated with higher weight, BMI, and WC in normal exercise capacity perimenopausal/ menopausal women.*

Keywords: *Neck circumference, Anthropometry, Cardio-metabolic risk, Exercise capacity, Perimenopausal women, Menopausal women*

J Med Assoc Thai 2016; 99 (Suppl. 7): S55-S61
Full text. e-Journal: *http://www.jmatonline.com*

Cardiovascular disease (CVD) prevention is predicated on the identification of risk factors in asymptomatic individuals in worldwide. Screening tools that include additional biomarkers may yield better predictive value for CVD risk factors and help identify those individuals who may benefit from more in-depth assessment. Neck circumference (NC) and traditional anthropometrics including waist circumference (WC), hip circumference (HC), and waist-hip ratio (WHR) may be useful in screening CVD risk. NC may represent a better parameter of cardiovascular risk, when compared to central obesity that fat stored in the visceral region[1], possibly because visceral fat is not the major source of free fatty acids circulating level[2]. Previous studies were done in difference parameters such as the larger the NC, the higher the cardio-metabolic risk in obesity, sleep apnea children, and adult population[3-5]. The validity of using NC as a surrogate marker of health risk is supported by its correlation with cardio-metabolic risk factors in adults in Asian and Caucasian population[6-8].

The predictive potentials of NC for cardio-metabolic risks in perimenopausal and menopausal women remain uncertain. The hypothesis of the present study was that women with higher NC values had more cardio-metabolic risk factors as compared to those with

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lower NC values.

The aim of this study was to investigate whether NC independently contributes to the prediction of cardio-metabolic risks as anthropometric parameters; body mass index (BMI), WC and WHR.

Material and Method

Study population

This is a cross-sectional study involving 76 perimenopausal and menopausal participants recruited from cardiovascular clinic and menopause clinic, aged from 40 to 70 years who underwent exercise stress test in Suranaree University of Technology Hospital between September 2015 and February 2016. For the assessment of guidelines for clinical exercise testing laboratories from American Heart Association, we selected sample by excluding participants with history of hormonal replacement therapy, any of the following overt CVD and cardiovascular equivalence conditions: history of stroke including cerebral infarction or transient ischemic attack, myocardial infarction, heart failure, end stage renal disease and inability to walk. The study has been reviewed and approved by the Ethics Committee for Research Involving Human Subjects, Suranaree University of Technology. Informed consent was obtained from both groups and ethical clearance was obtained from the relevant authority.

Sample size was calculated from

$$n = \frac{Z_{1-\alpha/2}^2 \, p \, (1 - p)}{d^2}$$

In this formula, p is the prevalence of abnormal exercise stress test (EST) in perimenopausal and menopausal women of pilot study at Suranaree University of Technology Hospital (5%), d is the standard error (5%).

Study protocol

This is a cross-sectional study, carried out between September 2015 and February 2016 with perimenopausal and menopausal women in Suranaree University of Technology Hospital, Thailand. After signing the informed consent form, 76 women voluntarily participated in the investigation. Based on NC cut-off point values in female was introduce in this study same as previous studies in Asian population. The participants were divided into two groups: NC <35 cm and NC ≥35 cm. The inclusion criteria were 1) age 40 to 70 years, 2) signing the consent form, 3) submitted to all laboratory and anthropometric tests. The exclusion criteria were having neck deformity, goiter, and hypertrophy of parotid glands.

Anthropometry

The body mass measurement was taken with the individual wearing light clothes and bare feet, using digital scales with capacity of 150 kilograms (kg), and 100 grams divisions. Height was measured by a wall stadiometer with capacity of 2,200 millimeters (mm) and 1 mm divisions.

The WC was measured with the participant standing up, with minimal clothing as possible, midway between the last floating rib and the iliac crest.

The NC was measured using a measuring tape. The participants were asked to stand erect, with their head positioned in the Frankfort horizontal plane. The upper edge of the measuring tape was placed just below the laryngeal prominence and applied perpendicularly to the long axis of the neck.

Laboratory measurement

Baseline serum specimens (stored at the central repository) were measured for levels of glucose and lipids. Serum fasting blood sugar (FBS), total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) were measured by the central laboratories of Suranaree University of Technology Hospital.

Exercise stress test (EST)

All exercise tests were done on a motorized treadmill using the modify Bruce protocol. Exercise testing procedures outlined by the American Heart Association were followed for all assessments. All patients were continuously monitored with 12-lead electrocardiography (ECG), and hemodynamic measurements were made during each stage of the protocol. Blood pressure was measured with an automated sphygmomanometer with auditory confirmation.

The following exercise test termination criteria were used: onset of severe typical angina, arrhythmias (frequent premature ventricular contractions; three or more beats of non-sustained ventricular tachycardia; new onset atrial fibrillation, atrial flutter, or atrial tachycardia with rapid response; second degree or third degree heart block), hypotension, bradycardia, or decrease in heart rate (HR) with same or greater workload, dyspnea, intermittent claudication, central

nervous system symptoms, marked hypertension, more than 2 mm of horizontal or down sloping ST segment depression or 1 mm or more of ST segment elevation, and participant's request to stop or inability to keep up with the treadmill.

Definition of terms

Perimenopausal women

Participants were also asked about their menstrual bleeding patterns in the 12 months prior to recruitment. Perimenopausal women are referred to women age ≥40 years around menopause and had menstrual periods irregularity in the past 12 months.

Menopausal women

Menopausal women are referred to women those with no menstrual periods within the last 12 months.

Functional capacity

Participants ≥5 metabolic equivalent of task (METS) in female were diagnosed with normal exercise capacity by the American Heart Association definition.

Statistical analysis

The significance level for all variables studied was $p \leq 0.05$. Initially a descriptive analysis of the variables was carried out with central trend and dispersion measurements. The NC cut-point was divided into <35 cm and ≥35 cm to compare relative anthropometric data, blood pressure, and biochemical tests by independent t-test. In addition, the correlation between NC and cardiovascular risk factors was evaluated, as well as the relative strength by means of Pearson's correlation for lipid profile.

Results

Mean and standard deviation (SD) of demographic data and clinical characteristics of menopausal status both perimenopausal and menopausal women were analyzed. The study population consisted of 76 participants, mean age 50.26±8.36 years and mean NC 33.51±3.14 cm. Normal functional capacity functional was shown in this study (8.44±2.18 METS). None of the participants had signs of myocardial infarction on the resting ECG or significant myocardial ischemia during stress exercise. None of the subjects reported experiencing chest pain during the EST (Table 1).

NC revealed a positive correlation with anthropometric parameters; weight ($r = 0.72$, $p<0.01$), BMI ($r = 0.72$, $p<0.01$), WC ($r = 0.65$, $p<0.01$) and cardio-metabolic laboratory parameters FBS ($r = 0.23$, $p = 0.04$), TG ($r = 0.31$, $p<0.01$). In contrast, NC was negatively correlated with HDL-C ($r = -0.44$, $p<0.01$) (Table 2).

Perimenopausal and menopausal women with greater NC presented more cardiovascular risk factors anthropometric parameters; weight, BMI, WC, and laboratory parameters; HDL-C as compared to women

Table 1. Anthropometric and cardio-metabolic characteristics

Clinical characteristics	Mean ± SD
Age (years)	50.26±8.36
Systolic blood pressure (mmHg)	122.08±13.34
Diastolic blood pressure (mmHg)	66.88±8.57
Height (cm)	155.93±5.29
Weight (kg)	60.42±11.75
Body mass index (kg/m^2)	19.35±3.58
Waist circumference (cm)	81.61±9.96
Waist-hip ratio	0.83±0.05
Neck circumference (cm)	33.51±3.14
Fasting blood sugar (mg/dL)	93.97±19.67
Total cholesterol (mg/dL)	202.93±40.48
Triglyceride (mg/dL)	126.88±81.82
High-density lipoprotein cholesterol (mg/dL)	50.86±15.16
Low-density lipoprotein cholesterol (mg/dL)	119.86±34.66
Peak rate pressure product	26,158.86±4,788.53
Heart rate recovery at 1 min (bpm)	23.18±8.81
Functional capacity METS	8.44±2.18

with lower NC values, all $p<0.01$ (Table 3).

Discussion

The objective of the present study was to compare and associate cardiovascular risk factors in normal exercise capacity perimenopausal and menopausal women with different NC measurements. Perimenopausal and menopausal women with greater NC presented more cardiovascular risk factors as compared to women with lower NC values, which is the

Table 2. Correlation between cardio-metabolic risk factors and NC values

Cardio-metabolic risk factors	Neck circumference	
	r	*p*-value
Systolic blood pressure	0.14	0.22
Diastolic blood pressure	0.11	0.33
Weight	0.72	<0.01*
Body mass index	0.72	<0.01*
Waist circumference	0.65	<0.01*
Waist-hip ratio	0.20	0.09
Fasting blood sugar	0.23	0.04*
Total cholesterol	-0.11	0.36
Triglyceride	0.31	<0.01*
High-density lipoprotein cholesterol	-0.44	<0.01*
Low-density lipoprotein cholesterol	0.11	0.37
Peak rate pressureproduct	0.11	0.31
Heart rate recovery at 1 min	-0.13	0.26
Functional capacity METS	-0.11	0.36

* Correlation is significant at the 0.05 level

Table 3. Anthropometric parameters, lipid profiles and EST difference between NC groups.

Cardio-metabolic risk factors	Neck circumference		*p*-value
	<35 cm	≥35 cm	
Age (years)	49.73±8.16	51.18±8.77	0.47
Systolic blood pressure (mmHg)	121.88±14.58	122.43±11.14	0.86
Diastolic blood pressure (mmHg)	68.60±8.87	69.36±8.17	0.71
Anthropometry			
Weight (kg)	55.60±8.53	68.67±12.04	<0.01*
Body mass index (kg/m^2)	17.90±2.53	21.84±3.78	<0.01*
Waist circumference (cm)	77.77±8.10	88.04±9.70	<0.01*
Waist-hip ratio	0.83±0.05	0.84±0.05	0.17
Laboratory			
Fasting blood sugar (mg/dL)	92.56±19.66	96.39±19.81	0.42
Total cholesterol (mg/dL)	206.79±44.28	196.32±32.66	0.28
Triglyceride (mg/dL)	109.46±71.77	156.75±90.36	0.01
High-density lipoprotein cholesterol (mg/dL)	55.17±14.94	43.46±12.64	<0.01*
Low-density lipoprotein cholesterol (mg/dL)	121.65±35.29	116.79±33.96	0.56
Exercise stress test			
Peak rate pressure product	25,632.71±5,323.06	27,060.82±3,610.38	0.21
Heart rate recovery at 1 min (bpm)	23.50±9.01	22.64±8.46	0.69
Functional capacity METS	8.72±2.20	7.95±2.07	0.14

* Difference is significant at the 0.05 level.

same as previous study in Asian general population but difference NC cut-off value[9]. NC cut-off of greater than 35 cm in women for the prediction of cardio-metabolic risk in this population is the same as other Asian and China populations. Cut-off value was in consistent with previous studies[10]. Greater differences in body size might partially explain the heterogeneity in the optimal cut-off of NC as WC among different population[11]. WC measurements are easily affected by being full or hungry, respiratory movement and wearying heavy clothing, whereas these problems can be avoided in the NC measurement. In this regard, ethnic specific cut-off of NC would be required for the prediction of cardio-metabolic abnormalities.

In the previous studies, obesity is widely accepted to be associated with metabolic disorders and cardiovascular risk factor[11]. BMI, WC and WHR are widely used anthropometric indices to reflect obesity and predict cardio-metabolic risks[12,13], an increasing number of studies have suggested that NC is a simple, more innovative and practical anthropometric parameter. Few studies have compared the effect size of NC with WC, BMI, waist-height ratio (WHtR) or other anthropometric indices. Some studies but not all[8,14,15], observed a less strong association in NC than those of BMI, WC and WHR with metabolic abnormalities. From these results, we could not consider NC superior to BMI, WC and WHR to predict cardio-metabolic risks. It is well established that visceral fat has greater effect on the development of metabolic abnormalities than subcutaneous fat. The variety of studies have demonstrated that these indices of visceral fat WC, WHR and WHtR have stronger association with metabolic abnormalities or CVD risks than BMI[16]. Therefore, it was likely that the inefficient predictive value of NC in this study were due to its strong correlation with both visceral fat and subcutaneous fat when compared with general obesity (BMI) or central obesity (WC or WHR).

Physical inactivity is commonly associated with CVD especially in sedentary life style and obesity[17-19]. This study has normal exercise capacity from EST 8.44$\pm$2.18 METS and intermediate to high peak rate pressure product (PRPP) which gives an accurate reflection of the myocardial oxygen demand and myocardial workload at peak of exercise developed by the left ventricle[20]. The ability to reach higher PRPP is associated with more adequate coronary perfusion and good prognosis.

The present study has some limitations. This cross-sectional design study limited extension of its interpretation to the causality of associations.

Conclusion

In perimenopausal/menopausal women, NC plays as an independent contributor in predicting the metabolic abnormalities comparable with the classical anthropometric indices of weight, BMI, and WC, even normal exercise stress test. NC may be used as an optimal screening tool for cardio-metabolic risks and other obesity related diseases. It must be emphasized that this tool is cheap and can be applied to large population to assess possible diseases and loss of functional capacity.

What is already known on this topic?

The present study is not the first report of NC and cardio-metabolic risk but previous studies cannot be directly applied to perimenopausal/menopausal specific subgroup in Thai population and different cut-off value of NC because of differences in ethnic groups and environmental factors in our study.

What this study adds?

However, it is important to observe a correlation between NC and cardio-metabolic risk in non-overt CVD with normal function exercise test, which is of great significance in reducing the incidence of CVD among perimenopausal/menopausal women.

Acknowledgements

We thank all who participated in the study, the staff at cardiovascular clinic and menopause clinic of Suranaree University of Technology Hospital who assisted the study. This study is supported by the grant from Suranaree University of Technology.

Potential conflicts of interest

None.

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ความยาวของเส้นรอบวงคอและเมตาบอลิกในสตรีวัยใกล้หมดประจำเดือน/วัยหมดประจำเดือนที่มีสมรรถภาพการออกกำลังกายปกติ

ปัทมา ทองดี, พรทิพย์ นิ่มขุนทด

ภูมิหลัง: *การตรวจเพื่อคัดกรองด้วยเครื่องมือร่วมกับการตรวจเลือดวัดไบโอมาคเกอร์ถูกใช้ในการคาดการณ์สำหรับการเกิดโรคความดันโลหิตสูง ความทนทานต่อกลูโคสบกพร่องและโรคของหลอดเลือดหัวใจอื่น ๆ และช่วยในการชี้เฉพาะให้แต่ละบุคคลในการประเมินในเชิงลึกซึ้ง เส้นรอบวงคอเป็นการตรวจคัดกรองอย่างง่ายสำหรับการระบุความเสี่ยงโรคหัวใจและเมตาบอลิกในผู้หญิงวัยใกล้หมดประจำเดือนและวัยหมดประจำเดือน*

วัตถุประสงค์: *เพื่อประเมินว่าค่าเส้นรอบวงคออย่างเดียวสามารถใช้ในการระบุความเสี่ยงโรคหัวใจและเมตาบอลิกได้ เส้นรอบวงคอเปรียบเทียบกับค่าสัดส่วนของร่างกายดั้งเดิม ดัชนีมวลกาย และสัดส่วนรอบเอวต่อรอบสะโพก*

วัสดุและวิธีการ: *การศึกษาภาคตัดขวางในสตรีวัยใกล้หมดประจำเดือนและวัยหมดประจำเดือนทั้งหมด 76 คน ผู้เข้าร่วมวิจัยมีอายุ 40-70 ปี ที่ได้รับคัดเลือกจากโรงพยาบาลมหาวิทยาลัยเทคโนโลยีสุรนารีระหว่างเดือนกันยายน พ.ศ. 2558 จนถึงเดือนกุมภาพันธ์ พ.ศ. 2559 ทำการวัดสัดส่วน การตรวจทางห้องปฏิบัติการชีวเคมี และการวัดทางคลินิก เส้นรอบวงคอ ≥35 เซนติเมตร สำหรับสตรีเป็นจุดตัดความผิดปกติของเส้นรอบคอ ผู้เข้าร่วมทั้งหมดได้ทำทดสอบสมรรถภาพหัวใจเดินสายพาน*

ผลการศึกษา: *สตรีวัยใกล้หมดประจำเดือน/วัยหมดประจำเดือนจำนวน 76 คน เส้นรอบคอมีความสัมพันธ์เชิงบวกกับน้ำหนัก ดัชนีมวลกาย และค่ารอบเอว ($r = 0.72, 0.72$ และ 0.65 ตามลำดับ ทุกค่า $p<0.01$) และมีความสัมพันธ์เชิงลบกับค่าไขมันเอชดีแอล ($r = -0.44$, $p<0.01$) ผลตรวจทางห้องปฏิบัติการอื่น ๆ ระดับน้ำตาลในเลือด ($r = 0.23$, $p = 0.04$) และค่าไขมันไตรกรีเซอไรด์ ($r = 0.31$, $p < 0.01$) มีความสัมพันธ์เชิงบวก*

สรุป: *การวัดเส้นรอบคอเป็นวิธีที่ง่ายและประหยัดเวลาในการตรวจคัดกรองที่สามารถใช้ในการระบุความเสี่ยงโรคหัวใจและเมตาบอลิกได้ เช่นเดียวกับสัดส่วนของร่างกาย ดัชนีมวลกาย รอบเอว และผลตรวจทางห้องปฏิบัติการ ค่าระดับน้ำตาลในเลือด ไขมันไตรกรีเซอไรด์ และไขมันเอชดีแอล สำหรับสตรีวัยใกล้หมดประจำเดือนและวัยหมดประจำเดือนที่สมรรถภาพการออกกำลังกายปกติที่มีเส้นรอบวงคอมากกว่าหรือเท่ากับ 35 เซนติเมตร มีความสัมพันธ์กับน้ำหนัก ดัชนีมวลกาย และรอบเอวที่มากกว่า*