



Association of Dietary Carboxy Methyl Lysine in Adult Women With Central Obesity: A Cross-Sectional Study

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ABSTRACT

Introduction: The prevalence of central obesity, which is associated with the risk of hypertension and diabetes, has increased drastically, both globally and in Indonesia. Unhealthy dietary patterns, such as high sugar and high salt intakes, ultra-processed foods, and high dietary carboxymethyl lysine (dCML), are frequently associated with an increase in waist circumference (WC) that is used in evaluating central obesity. However, the results of Indonesian studies on dCML are still controversial and limited in number. Objective: to examine the association between dietary CML intake and central obesity among urban adult women at a Public Health Center (Puskesmas) in West Jakarta, Indonesia.

Methods: This analytical observational cross-sectional study was conducted from September to October 2024 among 104 healthy females aged 20 – 64 years, non-pregnant or non-lactating, non-diabetic, non-smoking, without ascites or abdominal tumors. Dietary intake of dCML was determined by 2 x 24-h food recall, while central obesity was deemed to be present at a waist circumference of ≥ 80 cm. Statistical analysis was done using SPSS version 30.0.0. Multivariate logistic regression was used to evaluate the relationship between dCML and central obesity, with statistical significance set at $p < 0.05$.

Results: Median ($p_{25} - p_{75}$) dCML was 3.7 (2.7 – 4.8) mgCML/day, with the majority of subjects (62.5%) having central obesity. Age was positively associated with obesity at $aOR=1.16$ [95%CI: 1.08; 1.25], $p<0.001$. In comparison with the low CML intake group, the group with CML intake >4.8 mg/day had a higher risk for central obesity at $aOR=4.75$ [95%CI: 1.17; 19.29], $p=0.029$.

Conclusion: Dietary CML was associated with central obesity in adult women. Further research should be conducted in older persons to increase public knowledge about CML and its influence on the health of this population group.

Keywords: Carboxymethyl lysine; Central obesity; Waist circumference; Women; Indonesia.

PENDAHULUAN

Central obesity is an important health problem that is attracting attention because it is associated with the risk of cardiovascular disease. The available data show that the prevalence of central obesity is increasing, both globally (Wong et al., 2020) and in Indonesia (Ferdina et al., 2024). It is known that in urban areas of Indonesia the prevalence of central obesity has increased drastically from 28% in 2007 to 57.2% in 2018 (Ferdina et al., 2024). Central obesity may be determined by several measures, such as the waist circumference (Indraswari et al., 2021), with a cut off at ≥ 80 cm for females in Asia-Pacific countries (Harbuwono et al., 2018; Mirmiran et al., 2019).

The etiology of central obesity is multifactorial, comprising factors such as old age, female sex, sedentary lifestyle, smoking, and an unhealthy low-fiber, high-salt, and high-fat diet containing

advanced glycation end products (AGEs) (Angoorani et al., 2016; Dahlia et al., 2022). There are many studies on AGEs, because these compounds are considered to be hazardous if accumulating in large amounts in the body (Niu et al., 2023; Zgutka et al., 2023). These compounds are formed by nonenzymatic reactions between sugars and proteins or fats. Foods are known to be major contributors of AGEs in the body, apart from age, smoking, and physical inactivity. The preparation of foods at low moisture content and high temperature for extended periods is known to increase the AGE content up to 100x (Uribarri et al., 2010). The differences in food types of various countries motivated researchers in each of these countries to construct a database of carboxymethyl lysine (CML) contents of local foods, as biomarker of AGEs in foods as well as in the body (Goldberg et al., 2004; Hull et al., 2012; Scheijen et al., 2016; Zhang et al., 2024). In a previous study we developed a database of CML contents of 210 types of Indonesian foods (Liman et al., 2024), which served as a reference for the present study.

We also conducted a study on 235 Minangkabau and Sundanese females aged 19-50 years in rural mountainous and coastal areas in Indonesia. The results demonstrated that dietary CML (dCML) has a direct effect on plasma CML, with each increment of 10 mg CML/day raising plasma CML by 14.4 ng/mL, thereby indirectly increasing the waist circumference (WC) by 3.3 cm, at $p < 0.001$ (Patricia B. Liman et al., 2019). The above-mentioned relationship between dCML and WC has been associated with increases in oxidative stress, inflammatory cytokines, and insulin resistance (Parwani & Mandal, 2024; Y. Zhang et al., 2025). Differing results were shown by the study of Ghorbaninejad et al. who did not find any relationship between CML and WC in 265 Iranian subjects ($p > 0.05$) (Ghorbaninejad et al., 2021).

Evaluation of dCML in women is important, in view of the need for controlling the prevalence of central obesity in women and of the fact that urban areas in Indonesia are at an increased risk of obesity (Ferdina et al., 2024). As far as we know, up to the present there have been no studies on dCML that are using a database of AGEs in Indonesian foods of urban areas. Therefore it is necessary to conduct a study for evaluating dCML and its relationship with WC in adult women in Jakarta, Indonesia.

METHODS

This analytical observational cross-sectional study was conducted among 104 female employees of the Public Health Center in West Jakarta, Special Capital Region of Jakarta, from September to October 2024. The inclusion criteria were females aged 20-65 years, non-diabetic, not smoking, not suffering from ascites, having no history of abdominal tumors, not pregnant or lactating, and agreeing to participate in the study by signing informed consent. The participants were assigned by consecutive non-random sampling. This study obtained ethical clearance from the Research Ethics Committee, Faculty of Medicine, Universitas Trisakti, under number 015/KER/FK/08/2024 at August 5th, 2024 and study approval from the Municipal Health Office, West Jakarta Administrative City, under number 4574/TM.09.45.

The minimum sample size was calculated with the following formula:

$$\text{Eq. (1)} \\ n_0 = \frac{z^2 x p x q}{d^2}$$

where n_0 : required optimal sample size, Z_{α} : 1.96; p : prevalence of the central obesity group in DKI Jakarta = 45.7% = 0.457; q : (1- p) = 0.543; determined degree of confidence or accuracy of measurement = 0.05, resulting in $n_0 = 382$.

$$\text{Eq. (2)} \\ n = \frac{n_0}{1 + \frac{n_0}{N}}$$

Subsequently the resulting value was then adjusted by a finite population correction using formula (2). The number of females working as active employees at the data collection site being 115, the addition of 15% for drop-out risk resulted in the minimum sample size required in this study becoming 104.

Dietary AGE intakes were obtained using 2 x 24-h food recall (1 working day and 1 holiday) with the Nutrisurvey program version 2007 that was downloaded from <https://www.nutrisurvey.de>. The database on the CML contents of Indonesian foods that was used was taken from the study of Liman et al. (Liman et al., 2024) or if unavailable, were estimated from databases of other countries (Scheijen et al., 2016). Fruits and vegetables were not included in the estimation of dCML because of their low AGE content (Hull et al., 2012). The dCML results were grouped by quartiles.

Waist circumference was measured using a Seca 203 ergonomic measuring tape (Hamburg, Germany). The WC was measured according to the WHO STEPS protocol, namely at midpoint between the lower margin of the last palpable rib and the top of the iliac crest (WHO, 2008). The measurement was taken at the end of a normal expiration, to the nearest 0.1 cm, with the subject's arms relaxed at the sides, and the measuring tape not compressing the skin. The measurements were made in duplicate and then taking the mean of both measurements.

The statistical analysis was done using SPSS version 30.0.0. To determine the correlation between two groups of continuous data, either Pearson or the Spearman correlation test was used. Bivariate analysis results of the variables of age, macronutrient intake, and dietary CML at p value <0.25 were included as potential covariates. After the analysis showed the absence of multicollinearity, the multiple logistic regression analysis was conducted. The significance level was set at p value <0.05. The Hosmer-Lemeshow test was used to test the goodness of fit of the final model of multiple logistic regression with a good fit model at p>0.05. Crude and adjusted odds ratios (OR and AOR) with 95% confidence intervals were calculated.

RESULTS

Table 1. Subject characteristics (n=104)

Variable	Mean±SD / Median (p25 – p75)	n	%
Age (years)	33.0 (28.0 – 39.0)		
Early adulthood		65	62.5
Middle adulthood		39	37.5
Dietary intake per day			
Energy (kcal)	1582 ± 549		
Protein (g)	60.9 (43.6 – 74.7)		
Protein (%TE)	15.7 (12.6 – 19.4)		
Fat (g)	60.9 ± 27.6		
Fat (%TE)	34.0 ± 8.2		
Carbohydrate (g)	161.4 ± 61.4		
Carbohydrate (%TE)	41.1 ± 7.9		
Dietary CML (mg/day)	3.7 (2.7 – 4.8)		
Low		26	25.0
Middle		53	51.0
High		25	24.0
Waist circumference (cm)	83.5 (76.0 – 91.4)		
Central obesity			
No		39	37.5
Yes		65	62.5

Abbreviations: CML: Carboxymethyl lysine; TE: total energy; Low CML intake: <2.65 mg/day; Middle CML intake: 2.65 – 4.8 mg/day; High CML intake: >4.8 mg/day; Central obesity: waist circumference ≥80 cm; Early adulthood: 20-35 years old; Middle adulthood: 36-64 years old.

The results of the study showed a prevalence of central obesity of 62.5%, with the majority of subjects being in early adulthood (Table 1). Only one-fourth of the subjects had low CML consumption. The mean $\pm$ SD of calorie intake was 1582 ± 549 kcal per day, while the intakes of protein, fat, and carbohydrate were 15.7 (12.6 – 19.4)%, $34.0 \pm 8.2\%$, and $41.1 \pm 7.9\%$, respectively.

Table 2 shows that in the bivariate analysis the variables of energy, protein, fat, and carbohydrate intakes met the criteria of potential covariates, at $p < 0.25$. However, energy intake was strongly correlated with the intakes of fat and carbohydrate at $r = 0.876$, $p < 0.001$ and $r = 0.868$, $p < 0.001$, respectively. A strong correlation was also apparent between energy and protein intakes, at $r = 0.683$, $p < 0.001$. Our previous study (Patricia B. Liman et al., 2019) showed a relationship between energy intake and dietary CML, this being the reason why energy and protein intakes were chosen to be entered in the multiple regression analysis.

Age was positively associated with the incidence of obesity in adult women at $OR = 1.14$ [95%CI: 1.07; 1.21], $p < 0.001$. This result was still significant after adjustment with the covariates dCML and macronutrient intake at $OR = 1.16$ [95%CI: 1.08; 1.25], $p < 0.001$. The present study did not find any relationship between energy intake and the incidence of central obesity, at crude $OR = 1.00$ [95%CI: 1.00; 1.00], $p = 0.065$, and the result still being non-significant after adjustment with age, protein intake, and dCML intake. Protein intake was associated with the incidence of obesity at crude $OR = 1.02$ [95%CI: 1.00; 1.04], $p = 0.031$, but the relationship was non-significant after adjustment with age, energy, and dCML.

Table 2. Bivariate and multivariate logistic analysis (age, macronutrient intake, and dietary CML) versus Central obesity (n=104)

Variable	OR (95%CI)	p	aOR (95%CI)	p
Age (years)	1.14 (1.07; 1.21)	<0.001	1.16 (1.08; 1.25)	<0.001
Energy (kcal)	1.00 (1.00; 1.00)	0.065		
Protein (g)	1.02 (1.00; 1.04)	0.031		
Fat (g)	1.01 (1.00; 1.04)	0.090		
Carbohydrate (g)	1.00 (0.99; 1.01)	0.240		
Dietary CML				
Low	Ref		Ref	
Middle	1.41 (0.55; 3.66)	0.475	1.55 (0.52; 4.62)	0.427
High	2.20 (0.69; 7.07)	0.184	4.75 (1.17; 19.29)	0.029

Abbreviations: CML: Carboxymethyl lysine; Low CML intake: < 2.65 mg/day; Middle CML intake: $2.65 - 4.8$ mg/day; High CML intake: > 4.8 mg/day; Central obesity: waist circumference ≥ 80 cm;

The bivariate analysis demonstrated that the high CML-intake group had a risk for central obesity, as compared with the low CML-intake group, but the relation was statistically not significant, at $OR = 2.22$ [95%CI: 0.69; 7.07], $p = 0.184$. However, after adjustment with age and macronutrient intake, the high CML-intake group was at higher risk for central obesity, as compared with the low CML-intake group, at $OR = 4.75$ [95%CI: 1.17; 19.29], $p = 0.029$. The group with middle dietary CML was also at higher risk for central obesity in comparison with the low CML group, but the relationship was statistically not significant ($OR = 1.41$ [95%CI: 0.55; 3.66], $p = 0.475$). The result was still not significant after adjustment with covariates. In this modeling exercise, the Hosmer-Lemeshow test p value was 0.073, while the Nagelkerke r -squared was 30.7%.

DISCUSSION

The results of this study showed that the prevalence of central obesity was far higher (at 62.5%) than that found in other Southeast Asian countries, such as the Philippines, Sri Lanka, Vietnam, and Bangladesh, at 22.4%, 16.2%, 15.4%, and 15.3%, respectively (Wong et al., 2020). However, our

figures agree with the Indonesian Health Survey data for 2023, with a prevalence of central obesity of 59.1% in women of the Special Capital Region of Jakarta (Indonesian Health Survey, 2023). The variables of female sex, older age, and urban area carried a higher risk of central obesity (Wong et al., 2020). In resolving the problem of central obesity, it is necessary to search for preventive strategies and management programs, such as by conducting periodical determinations of WC, by providing education, or by changing lifestyles (Ferdina et al., 2024).

The dietary CML value of 68% for female employees in urban areas (Jakarta) was higher than that found in our previous study on women of Indonesian rural areas, with dCML of 2.2 mgCML/day. These results were also higher than the dCML values in European adults in the studies of Cordova et al. (Cordova et al., 2020) and of Scheijen et al. (Scheijen et al., 2018) with 2.2 mgCML/day and 3.1 mgCML/day, respectively. This may have been caused by differences in food types and the availability of foods in each region. In European foods, the types of fish comprised more deep-sea fish conserved by canning or smoking, whereas Indonesian foods comprised more shallow ocean fish conserved by sun-drying (Patricia Budihartanti Liman et al., 2019). Fast food preparations processed at high temperatures, low water content, and long cooking times, as well as factory-processed foods, are known to have a high CML content (Kataoka, 2025; Zhang et al., 2024; Q. Zhang et al., 2025). The availability of these foods around residential areas with unhealthy food environments may also affect their nutritional status. Van Erpecum et al. (van Erpecum et al., 2022) conducted a cross-sectional study on 167,729 adults in the Netherlands to evaluate the relationship between fast-food outlet exposure and BMI. Their study showed that with two or more fast-food outlets within 1 km from residential homes, persons in urban areas had a higher BMI of 0.32 kg/m², in comparison with persons without fast-food outlets around their residences. The increase in processed food intakes frequently associated with increased CML contents (Koyama et al., 2022), is also seen in Indonesia, especially in urban areas such as Jakarta (Nurhasan et al., 2024).

Each yearly increment in age increases the risk of central obesity by 16%. This finding agrees with the study of Abbasifard et al. (Abbasifard et al., 2023) showing a positive association between age and central obesity ($p < 0.001$). Advancing age may strengthen the association between CML intake and WC. This was shown in the bivariate test by the non-significant relationship with dietary CML ($p > 0.05$), which however became significant after adjustment by age ($p < 0.05$).

In one study, during a five-year observation period the group with high intakes of AGE products, such as CEL, CML, and MG-H1, showed a higher increase in body weight than did the group with low AGE intakes (Cordova et al., 2020). The results remained significant even after adjustment for total energy intake (kcal/day) and other factors, such as smoking status, level of physical activity, and educational level. It has been estimated that 20-50% of the CML absorbed in the intestines is excreted in the urine and feces (Kellow & Savige, 2013; Zheng et al., 2022), while some is believed to be accumulated (Zheng et al., 2022).

CML stimulates hypertrophic adiposity through several mechanisms, such as down-regulation of adiponectin and glucose transporter type 4, which subsequently disturbs adipokine secretion, glucose uptake, and insulin signaling, thereby resulting in insulin resistance (Y. Zhang et al., 2025). Modifications in food preparation, such as processing foods by boiling, stewing, and steaming, can be reduce the formulation of CML. Marinating meat with lemon juice or vinegar may also reduce CML production by 50% during high-temperature food processing. The use of spices or seasonings, such as curcumin, rosemary, and other natural antioxidants, may inhibit AGE biosynthesis (Rungratanawanich et al., 2021).

The intakes of energy and macronutrients (protein, fat, and carbohydrate) in the present study agree with those in the study by Sistia et al. (Sistia et al., 2023) who evaluated the dietary intake among 467 Indonesian women aged 20-49 years. Similar results were found by Andarwulan et al. (Andarwulan et al., 2021) who evaluated the food consumption pattern of 58 adult females in South Jakarta for 2

days, using the weighed food record method. Their study showed a mean $\pm$ SD energy intake of 1579 ± 537 kcal per day. On the other hand, our study found a higher fat intake than that in the study of Andarwulan, where fat intake in females was 49 gram/capita/day. This discrepancy may have been caused by the timing of the data collection. It is common knowledge that the consumption of fat has been increasing from year to year. A cohort study in the city of Bogor showed an increase in fat intake of 10.7gram/day, namely from 55.7 ± 26.6 g/day in 2014 to 66.4 ± 34.5 g/day in 2016. This increase in fat intake should receive special attention, particularly if the fats consumed are saturated or trans fats.

Our study showed that an increase of one gram in protein intake may increase the probability of central obesity by 2%. The positive direct association between protein intake and central obesity was also found by Arini et al.(Arini et al., 2024), in that each increment in protein intake of 1g/day was associated with an increase in WC of 0.05cm. When analyzed by multiple logistic regression, the group with high protein intake is at higher risk of central obesity than is the group with lower protein intake, at OR = 1.01 [95%CI:1.00; 1.01] (Arini et al., 2024). Protein is known to be able to increase thermogenesis, promote satiety by increasing anorexigenic hormone levels(Moon & Koh, 2020) and by increasing hepatic gluconeogenesis and ketogenesis, which may help in reducing weight (Simonson et al., 2020). However, restrictions in daily calorie intake should also be instituted as part of the treatment of obesity(Moon & Koh, 2020). When only the type of protein is considered, this study did not show a positive relationship of meat and other animal-based protein with developing overweight/obesity (Bricarello et al., 2025; Sistia et al., 2023). Other study showed vegetable protein intake has a negative relationship with obesity (Sistia et al., 2023).

As far as we know, this is the first study that evaluated the CML intakes in women of urban areas by using an Indonesian food database. These data constitute valuable additional information on the CML intake of Indonesian communities. Nevertheless, this study has several limitations. Firstly, there are still food types that are not listed in the Indonesian database, such as those containing fish and entrails (offal). Determination of CML concentration in foods, especially foods in the fish and entrails category, should be conducted as a complement to the database of CML in Indonesian foods. Secondly, this study was limited to one study setting, namely a single Public Health Center (Puskesmas), and used non-random sampling. Further studies should be conducted in a larger setting, using a larger sample with stratified random sampling. Another limitation is that this study used 2x24-hour food recall, such that the results depended on the subjects' memory. The investigators tried to minimize bias by using a 4-step multiple-pass 24-hour dietary recall, with the help of a book of food photographs (Ministry of Health of the Republic of Indonesia, 2014).

CONCLUSION

Dietary CML among urban women in Jakarta was 3.7mgCML/day. A significant association was identified between high dCML and central obesity in adult women in Jakarta. Education on restriction of dCML intakes may be conducted to reduce the risk of central obesity, particularly in older women of the present population. Further studies in other urban areas may be conducted to obtain an overview of the CML intakes in all Indonesian communities.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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