Original Article

Chronic low grade inflammation measured by dietary inflammatory index and its association with obesity among school teachers in Yangon, Myanmar

Khin Mittar Moe San MSc[1,2,3], Umi Fahmida PhD[1], Fiastuti Wijaksono PhD[2], Htin Lin MSc[4], Ko Ko Zaw PhD[5], Min Kyaw Htet PhD[6]

[1]*Southeast Asian Ministers of Education Organization Regional Center for Food and Nutrition (SEAMEO-RECFON), Universitas Indonesia, Indonesia*
[2]*Nutrition Department, Faculty of Medicine, Universitas Indonesia, Indonesia*
[3]*Department of Medical Research, Ministry of Health and Sports, Myanmar*
[4]*State Public Health department (Northern Shan State), Ministry of Health and Sports, Myanmar*
[5]*University of Public Health, Ministry of Health and Sports, Myanmar*
[6]*Center of Community Health and Population Studies, The Research Institute, Trisakti University, Indonesia*

Background and Objectives: This study was aimed to investigate the association between obesity and chronic low grade inflammation (CLGI) measured by Dietary Inflammatory Index (DII) as a proxy indicator of CLGI among obese and non-obese teachers. **Methods and Study Design:** We conducted a cross sectional study among 128 non-obese (BMI <25) and 116 obese (BMI ≥25) female teachers aged 25-60 years from six urban schools in Yangon, Myanmar between January and March 2015. Usual dietary intake was collected by 3-day non-consecutive estimated 24 hour's dietary records and semi-quantitative Food Frequency Questionnaires. Adapted DII was calculated by standardized methods using literature-derived population-based dietary inflammatory weights of 31 food parameters. C-reactive protein (CRP) was analysed by a sandwich Enzyme-Linked Immuno-sorbent Assay (ELISA) technique. Mean DII between obese and non-obese was compared by independent t test. The association between obesity indices and high DII (DII ≥1.1) and high CRP (>3 mg/L) were investigated by logistic regression. **Results:** Obese teachers had lower intakes of anti-inflammatory nutrients (vitamin B-6, vitamin A and zinc)/food (onion) compared with non-obese teachers (*p*<0.05) and obesity was significantly associated with CRP (Odd ratio (OR)=5.5, 95% Confidence interval (CI) 1.2-24.1, *p*=0.02). However, there was no significant association between obesity and DII (OR=1.4, 95% CI -0.8-2.3, *p*=0.23). **Conclusions:** Role of anti-inflammatory foods should be promoted for prevention of obesity and related diseases. Further use of DII among Myanmar general population for prevention of obesity and its related diseases should be explored with longitudinal studies.

Key Words: obesity, chronic low grade inflammation, dietary inflammatory index, urban women, Myanmar

INTRODUCTION

Nowadays, one third of world's population from both developed and developing countries are facing problems of overweight and obesity.[1] According to WHO 2009 MYANMAR STEP survey, one fourth of Myanmar population were overweight and obesity and it has become a public health concern.[2] Obesity is one of the major metabolic risk factors of non-communicable diseases (NCD) which accounts for 63% of the mortality globally, 55% of the mortality in South East Asia Region and 40% in Myanmar.[3]

The association between obesity and chronic low grade inflammation accompanied by elevated circulating pro-inflammatory biomarkers has been reported earlier. Findings from those studies suggest that chronic low grade inflammation plays a fundamental role in the process of metabolic syndrome and NCD.[4,5] In recent years, the relationship between chronic low grade inflammation and specific nutrient components[6,7] as well as dietary pattern have been investigated;[8-11] the findings showed a positive correlation between pro-inflammatory diets and chronic low grade inflammation and obesity.[12]

Beyond specific nutrients, the overall inflammatory potential of diet has become a special interest for dietary recommendation in prevention and control of chronic low grade inflammation and its complications.[13,14] Recently, a

Corresponding Author: Dr Khin Mittar Moe San, Research Officer, Nutrition Research Division, Department of Medical Research, No (5), Ziwaka Road, Dagon Township, Yangon, Myanmar 11191.
Tel: +959428167700; Fax: (+95)1 - 251514.
Email: khinmitta@gmail.com; kyawhtet@gmail.com
Manuscript received 05 May 2016. Initial review completed 26July 2016. Revision accepted 27September 2016.
doi:10.6133/apjcn.042017.06

dietary inflammatory index (DII) was developed as a new tool to categorize the individual 'diets on a continuum from maximally anti-inflammatory to maximally pro-inflammatory.[15,16] This DII was applicable as a predictor of C-reactive protein (CRP) and a proxy-indicator of chronic low grade inflammation.[17] DII was associated with other risk factors such as higher concentration of glucose metabolism markers, shift working status, anthropometric measures of obesity and inflammatory biomarkers[18-20] and survival rate, hospital stay and inflammatory gene interaction of colorectal cancer.[21,22]

In Myanmar, thirty three per cents of women aged between 25-64 years have been reported to be overweight (BMI >25), which was two-times higher than men (17.7%); the highest prevalence was among women aged between 35-54 years according to WHO 2009 MYANMAR STEP.[2] Obese mothers have a greater chance to have a big baby and this is positively correlated with risk of childhood obesity that can lead to intergenerational transfer of obesity and non-communicable diseases.[23,24] Among urban working women, school teachers are most vulnerable for non-communicable disease because of their life styles and the nature of their jobs.[25,26] In the present study we investigated the association between obesity and chronic low grade inflammation (CLGI), measured by dietary inflammatory index (DII) or CRP, among female school teachers in Yangon, Myanmar.

MATERIALS AND METHODS

Study design, subjects and ethics approval

This study was conducted as a comparative cross sectional study in Dagon Myothit township of Yangon Division in Myanmar during January-March 2015. At a screening phase, brief medical history and anthropometry assessment were taken to a total of 336 school teachers from six schools. Obese (143) and non-obese (143) female school teachers aged between 25-60 years were recruited. Those who had been diagnosed and taking regular treatment for chronic diseases such as diabetes, hypertension, heart disease and hyper-lipidemia and cancer, and had severe infection, major trauma and being pregnant were excluded from the study.

Ethical approval was obtained from the Human Ethics Committee of Faculty of Medicine, University of Indonesia (220/UN2.F1/ETIK/2015) as well as from the Ethical Committee on Medical Research involving Human subjects, Department of Medical Research, Lower Myanmar, Ministry of Health and Sports, and Myanmar (6/Ethics 2015).

Methods

Data on demographic characteristics were obtained using a self-administered structured questionnaire. Trained enumerators performed anthropometric measurements including weight, height and waist circumference by using standard procedure and SECA machines. Body fat mass was measured by a portable standard body composition monitor BC 541 TANITA machine using Bioelectrical Impedance Analysis (BIA).[27] Complete dietary data was obtained from 116 obese and 128 non-obese subjects. Serum C-reactive protein was measured by a sandwich ELISA technique.[28]

Dietary assessment

The respondents who agreed to participate in the study were trained how to record self-reported 24 hour dietary recall and they were requested to complete 3-day non-consecutive estimated 24 hour dietary records. Validated food photographs, household measures (the bowls and plates) and calibrated household utensils were provided for portion size estimation together with guidelines for 24 hours estimated dietary records and an example of completed form. They were also interviewed in order to complete semi-quantitative food frequency questionnaires. Among food parameters of the dietary inflammatory index, spices such as onion, garlic, ginger, tea, turmeric and pepper are commonly used as basic ingredients in preparation of Myanmar traditional food and they have a high inflammatory score; these foods were included. According to Myanmar unique culture, prickle tea was also included as a tea food item. Both raw and cooked foods were also weighed by a KD-160 TANITA food weighing machine to get an estimated standard portion.

The nutrient intake was estimated from non-consecutive 3-day estimated 24 hours' dietary records and SQFFQ. As Myanmar food composition database was not complete for all nutrients to be analyzed in this study, we mainly used Indonesian food composition database and some nutrient values were borrowed from Thailand, Malaysia, Singapore and USDA food composition databases.[29] A few cereal based foods and unique Myanmar traditional foods were directly used from the Myanmar food composition tables. Local recipes were calculated by weighing the raw materials and adjusted for cooking method. Food contents for beta-carotene, omega 3 and omega 6 were borrowed from Singaporean and USDA food composition databases, and adjusted for the water content.

Dietary inflammatory index

Adapted dietary inflammatory index was calculated from 31 food parameters that were available in our food composition database by using the standardized method as mentioned in Shivappa' study.[15] In that study; the Standard Global mean and standard deviation were developed from world composition database that was derived from 11 countries including 4 Asian countries. DII development was explained by calculation of adapted DII flow chart (Figure 1). In brief, z-score of usual intake from each food parameter was calculated by subtracting Standard Global mean from individual dietary data and divided by the standard deviation. Percentile value was converted to percentile rank in SPSS (0-100) and these values were divided by 100 to calculate the scoring of 0-1. After converting the centred percentile score which ranged from -1 to +1 for each food parameter, it was multiplied by respective overall food parameter-specific inflammatory effect score. Overall dietary inflammatory index (DII) was obtained from the sum of all of food parameter-specific Dietary inflammatory index (DII) scores. We had categorized high and low DII score by using the median value in our study that was consistent with the Bellvitge study.[21] A higher DII means high chronic low grade inflammation and a lower DII means low chronic low grade inflammation.

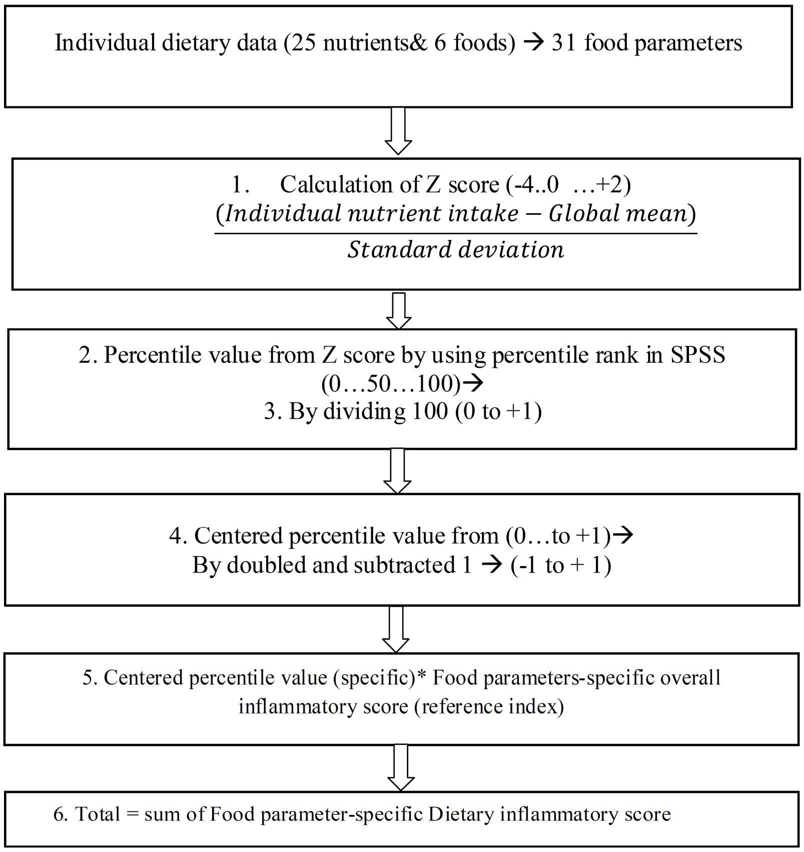

Figure1. Calculation of adapted DII flow chart

Statistical analysis

The data was processed and analyzed by using SPSS 16.0 version. The Kolmogorov-Smirnov goodness-of-fit test was used to check the normality of each variable. Descriptive characteristics were expressed as mean±SD for normally distributed data and median (IQR) for non-normal data. Comparisons of baseline characteristics by obesity status were made by independent sample t tests for continuous variables and association was assessed by using Chi-square tests for categorical variables. *p* value less than 0.05 was considered as statistically significant.

Body mass index, BMI (in Kg/m^2) was calculated as weight divided by height squared. Women were categorized into non-obese (BMI <25.0 kg/m^2) and obese (BMI ≥25.0 kg/m^2), abdominal obesity (WC ≥80 cm)[30] and high body fat mass (body fat mass >30%).[31] Physical activity (MET, Metabolic Equivalents: minutes/ week, continuous) was calculated according to WHO GPAQ guidelines.[32] The association between anthropometric indices of obesity (BMI, WC, body fat mass, obesity and abdominal obesity) and chronic low grade inflammation (Dietary Inflammatory Index as well as CRP) was assessed by chi-square test and logistic regression for categorical data.

RESULTS

In this study, 143 obese and 143 non-obese school teachers out of total 336 were recruited. Because of incomplete data of dietary records, 42 subjects were excluded. Among them, only 27.2% of school teachers were within normal BMI (18.5-22.9). Table 1 shows the baseline characteristics of obese and non-obese school teachers. Mean age, household number and physical activity between obese and non-obese school teachers were not significantly different. Half (53%) of school teachers were single; among the married women, multiparous women had high risk of obesity (OR-2.3, CI-1.0-5.2, *p* value-0.04). Family histories of non-communicable diseases, like hypertension and heart diseases, were positively associated with obesity risk (OR-1.0, CI-1.1-3.2, *p* value-0.02) and (OR-1.9, CI-1.1-3.2, *p* value- 0.02), respectively.

Table 2 describes the comparisons of food parameters including DII between two groups. The mean DII score in the present study was 0.9±1.9, which was higher in obese group although this was not statistically significant (1.1±1.9 in obese and 0.8±1.9 in non-obese (*p* value-0.29)). Obese teachers consumed significantly less specific anti-inflammatory food components or foods such as vitamin B6, vitamin A, zinc and onion compared with non-obese teachers. They also tended to consume less dietary fiber and turmeric (p<0.1) than non-obese subjects.

Table 3 describes the association between obesity status and DII status. There was a tendency of higher DII in obesity but this was not statistically significant. Table 4 shows that there was a significantly greater risk of higher CRP among obese school teachers, after adjusting for other confounders (OR=5.5 times, 95% confidence interval (CI) 1.2-24.1, p=0.02). There was similar trend for both high abdominal obesity and body fat mass, but these were not statistically significant.

DISCUSSION

The prevalence of obesity, abdominal obesity and high body fat among the teachers in the study area were high.

Table 1. Baseline characteristics of obese and non-obese school teachers

	Non-obese (n=128)	Obese (n=116)	*p* value*	OR (95%CI)
Respondent age	47 (36-54)†	50 (42-54)	0.25	-
Household number	4 (3-5)	4 (3-5)	0.84	-
MET total (mins/week)	4740 (2400-7380)	5040 (2628-6960)	0.91	-
Age (yr)			0.19	1.4 (0.9-2.4)
25-44	44.5%	36.2%	-	-
45-60	55.5%	63.8%	-	-
Marital status (married) (%)	38.3%	56.0%	0.01	2.1 (1.2-3.4)
Contraception (Yes) (%)	3.1%	9.5%	0.06	3.3 (1.0-10.5)
Multi-parity (>/=3 parity)	7.8%	16.4%	0.04	2.3 (1.0-5.2)
Family history of hypertension (Yes) (%)	53.1%	68.1%	0.02	1.9 (1.1-3.2)
Family history of diabetes mellitus (Yes) (%)	22.8%	31.3%	0.14	1.5 (0.9-2.7)
Family history of heart diseases (Yes) (%)	29.1%	43.5%	0.02	1.9 (1.1-3.2)
Family history of stroke (Yes) (%)	28.3%	21.7%	0.24	0.7 (0.4-1.3)

MET: metabolic equivalents.
†Median, IQR.
**p* value <0.05 is regarded as statistically significant.

Table 2. Comparison of nutrients and food intake of DII between obese and non-obese and global mean±SD and inflammatory effect score of DII

	Inflammatory effect score†	Global mean±SD‡	Non-obese (128)	Obese (116)	*p* value¶
Energy intake (kcal)	0.180	2056±338	1903 (1701-2177)§	1855 (1690-2061)	0.21
Vitamin B12 (µg)	0.106	5.15±2.7	0.8 (0.5-1.2)	0.8 (0.5-1.1)	0.36
Carbohydrate (g)	0.097	272±40.0	269 (244-302)	260 (235-293)	0.14
Cholesterol (mg)	0.110	279±51.2	82.9 (44.9-137)	80.4 (53.8-143)	0.78
Iron (mg)	0.032	13.4±3.7	9.7 (6.5-12.7)	9.3 (6.3-13.3)	0.96
Fat (g)	0.298	71.4±19.4	60.5±17.3¶	59.9±18.1	0.82
Protein (g)	0.021	79.4±13.9	54.3±13.5	51.7±12.9	0.13
Saturated fat (g)	0.373	28.6±8.0	9.3±3.6	8.8±3.5	0.32
Vitamin B6 (mg)	-0.365	1.47±0.7	0.7 (0.6-0.9)	0.7 (0.5-0.8)	0.02
Dietary fiber (g)	-0.663	18.8±4.9	6.2 (5.1-7.9)	5.8 (4.7-7)	0.08
Folic acid (µg)	-0.190	273±70.7	68.4 (51.7-95.9)	65.1 (46.8-87.3)	0.13
Magnesium (mg)	-0.484	310±139.4	159 (128-200)	155 (120-199)	0.37
Niacin (mg)	-0.246	25.9±11.8	9.8 (7.8-12.8)	9.9 (7.6-13.3)	0.70
PUFA (g)	-0.337	13.88±3.8	12.1 (8.3-16.3)	12 (8.8-15.3)	0.90
Vitamin B-1 (mg)	-0.098	1.7±0.7	0.6 (0.4-0.7)	0.5 (0.4-0.7)	0.82
Vitamin B-2 (mg)	-0.068	1.7±0.8	0.6 (0.5-0.7)	0.5 (0.5-0.7)	0.34
Vitamin A (RE)	-0.401	984±519	490 (291-779)	361 (260-604)	0.01
Vitamin C (mg)	-0.424	118±43.5	35.5 (24.7-56.0)	36.4 (24.5-50.8)	0.98
Vitamin D (µg)	-0.446	6.26±2.2	3.32 (0.8-5.6)	2.73 (1.3-5.4)	0.84
Vitamin E (mg)	-0.419	8.73±1.5	4.06 (2.8-5.4)	4.04 (3.105.42	0.60
MUFA (g)	-0.009	27.0±6.1	16.6±6.65	16.44± 6.7	0.90
Zinc (mg)	-0.313	9.84±2.2	4.2±0.94	4.0±1.0	0.02
Beta carotene (µg)	-0.584	3718±1720	592 (260-1280)	610 (201-1259)	0.97
Omega 3 (g)	-0.436	1.06±1.1	0.2 (0.2-0.4)	0.22 (0.2-0.4)	0.36
Omega 6 (g)	-0.159	10.8±7.5	8.2 (6.3-10.7)	7.9 (5.9-11.8)	0.83
Onion (g)	-0.301	35.9±18.4	28 (14-28)	14 (14-28)	0.03
Garlic (g)	-0.412	4.35±2.9	2.5 (1.2-2.5)	2.5 (1.2-2.5)	0.15
Ginger (g)	-0.453	59.0±63.2	3.5 (0.0-5.0)	3.5 (0.0-5.0)	0.84
Turmeric (mg)	-0.785	534±754.3	250 (120-250)	250 (120-250)	0.07
Pepper (g)	-0.131	10.0±7.1	0 (0.0-0.0)	0.0 (0.0-0.0)	0.83
Tea (g)	-0.536	1.7±1.5	1.0 (0.0-3.8)	1.0 (0.0-3.5)	0.82

†Food–parameter-specific overall inflammatory effect score; Shivappa et al, 2013, Dietary Inflammatory Index Development Study.
‡Global mean ± SD was from the world composite database; Shivappa et al, 2013, Dietary Inflammatory Index Development Study.
§Median (IQR) in such values.
¶Mean±SD in such values.
**p* value <0.05 is regarded as statistically significant difference between obese and non-obese using Independent T test and Mann-Whitney test.

Intake of some anti-inflammatory nutrients and food parameters was significantly lower in obese subjects. BMI was positively associated with CRP and obese women had higher risks for chronic low grade inflammation.

In this study, the energy intake of obese teachers was not higher than the non-obese teachers which might be due to their awareness or due to under-reporting as social desirability is likely amongst obese subjects.[33] As school

Table 3. Association between chronic low grade inflammation measured by DII and obesity

	LowerDII n (%)	HigherDII n (%)	Crude OR	95% CI	*p* value*	Adjusted OR†	95% CI	*p* value*
Obesity indices								
BMI <25 kg/m^2	68 (53.1)	60 (46.9)	1			1		
BMI ≥25 kg/m^2	53 (45.7)	63 (54.3)	1.4	0.8-2.2	0.25	1.4	0.8-2.3	0.23
Waistcircumference								
WC <80 cm	78 (52.3)	71 (47.7)	1			1		
WC ≥80 cm	41 (45.1)	50 (54.9)	1.3	0.8-2.3	0.27	1.4	0.8-2.4	0.25
Body fat mas								
≤30%	21 (50)	21 (50)	1			1		
>30%	95 (48.5)	101 (51.5)	1.1	0.6-2.1	0.86	1.1	0.5-2.1	0.85

WC: Waist circumference; CI: confidence interval; OR: odd ratio; MET: metabolic equivalents.
Logistic regression, *p value <0.05 is regarded as statistically significant.
Lower DII (<1.07) based on median & ROC sensitivity curve as reference.
4 Missing values in abdominal obesity; 6 Missing values in body fat mass.
†Adjusted by age, MET total, contraception, marital status, parity.

Table 4. Association between chronic low grade inflammation measured by CRP and Obesity

	Lower CRP n (%)	Higher CRP n (%)	Crude OR	95% CI	*p* value*	Adjusted OR†	95% CI	*p* value*
Obesity indices								
BMI <25 kg/m^2	21 (84)	4 (16)	1			1		
BMI ≥25 kg/m^2	11 (52.4)	10 (47.6)	4.8	1.2-18.8	0.03	5.47	1.2-24.1	0.02
Waistcircumference								
WC <80 cm	23 (74.2)	8 (25.8)	1			1		
WC ≥80 cm	8 (57.1)	6 (42.9)	2.2	0.6-8.2	0.25	3.59	0.8-16.9	0.10
Body fat mas								
≤ 30%	8 (88.9)	1 (11.1)	1			1		
>30%	24 (66.7)	12 (33.3)	4.0	0.5-35.8	0.25	4.34	0.5-11.2	0.21

WC: Waist circumference;CI: confidence interval; OR: odd ratio; MET: Metabolic equivalents.
Logistic regression, *p value <0.05 is regarded as statistically significant.
4 Missing values in abdominal obesity; 6 Missing values in body fat mass.
Lower CRP (≤3 mg/L) and higher CRP (>3 mg/L,)
†Adjusted by age, MET total, contraception, marital status, parity.

teachers in our study were higher educated persons, they have relatively better awareness than the community in general. This health consciousness may have influenced the obese participants in this study to manage their food intake. Moreover, we checked energy under-reporters using 99.7% CI Goldberg cut-off points, but there was no participants who under-reported their energy intake.[34]

The median DII score of original DII from all 45 food parameters was 0.2 and the range was between -8.9 (anti-inflammatory) to 8.0 (pro-inflammatory).[15] Yet, DII value was not consistent in different studies, depending on lists of food parameters and dietary assessment methods. We used 31 food parameters (25 nutrients and 6 specific foods) to calculate DII score and found the median (min-max) of our DII score was 1.1 (-3.9 to 5.9) and IQR (-0.5 to 2.3). In the Bellvitge study, Raul Zamora-Ros and researchers adapted DII from 36 food parameters and their median (IQR) of DII was 1.1 (-0.7 to 3.1) in the normal group.[22] Therefore, our median DII values were relatively consistent with the findings from Bellvitge study. In another study of DII and anthropometric measures of obesity PREDIMED trial in Spain, DII was developed from 34 food parameters and the median (min-max) DII was -0.8 (-4.9 to 3.7), lower than our findings.[19]

In the Asklepios study, developed DII from 17 food parameters by using FFQ, it was found that the mean DII score was -1.0±0.8,[35] in comparison with the mean DII value of 0.9±1.9 from the present study. In NHANES 2005-2010 study, Writh and coauthors assessed the difference of DII scores by shiftwork status among police workers.[20] Their DII was developed from 27 nutrients by using single 24 hours recall; they found a higher pro-inflammatory diet in shift-workers and an association between pro-inflammatory diet and glucose metabolism.[18,20] In the SEASON study, Shivappa validated the DII from two different dietary assessments and hs-CRP as a construct validator.[17] The mean values from both NHANES 2005-2010 study [0.9±1.1] and SEASON study [0.8±2.0] were comparable with our mean DII.

In our study, the overall consumption of pro-inflammatory food parameters including energy intake, carbohydrate, fat and PUFA were relatively comparable with both ASEAN Recommended Nutrients Intakes (RNI) and global mean intakes from world composition database.[15,36] Even though protein, vitamin A and zinc intake were far from global mean intakes, they still met ASEAN RNI.[15,36] Yet, intake of iron, folic acid, niacin, vitamin B-1, vitamin B-2, vitamin C and vitamin D were lower than ASEAN RNI.[36] However due to the short duration of dietary data captured in this study (last one week), the usual intakes of some of these nutrients may not be adequately represented. Despite these limitations, our data suggests that obese subjects had lower intakes of anti-inflammatory nutrients and foods including vitamin A, B-6, zinc and onion ($p<0.05$) and trend ($p<0.1$) for lower intakes of dietary fiber and turmeric.

This present study was the first study to investigate chronic low grade inflammation measured by DII with obesity status in a developing country. The previous studies on obesity and non-communicable disease in Myanmar mostly focused on the prevalence and risk factors assessment.[2,26,37] Our findings showed that consumption of anti-inflammatory food parameters was lower in obese school teachers and this was associated with a higher dietary inflammatory index among obese school teachers. These findings will be very useful for both individual nutrition counselling in prevention and treatment of obesity as well as dietary recommendation and nutrition education programs for prevention and control of non-communicable disease in Myanmar.

Our study also has some limitations to address. Cross-sectional study designs are limited to give strong association and cause and effect relationships. In terms of food parameters, we calculated 22 nutrients from 3 non-consecutive days and 6 foods from SQFFQ for the DII score, which was less comprehensive compared with previous studies. DII score was calculated from multiple (up to 15 days/person) and 7 days dietary recalls like SQ-FFQ in a previous validation study.[15] However, their findings suggested that ability to predict CRP was not attenuated when using more limited lists of DII food parameters and therefore we think the number of food items used for DII calculation in our study was acceptable.[35]Finally, the exclusion criteria of obese subjects having non-communicable diseases may have reduced the difference between healthy obese and non-obese subjects in our study.

For further studies, prospective cohort or intervention related with non-communicable diseases are needed to explore more effects of this dietary inflammatory index score. Since some micronutrient intakes may not be well represented, additional number of days for usual intake of micronutrients or validated SQ-FFQ should be applied to capture the intake of anti and pro-inflammatory nutrients and foods. Efforts to improve food composition tables, by upgrading more nutrients and food components, are also needed.

Conclusion

As our study included healthy obese subjects and non-obese subjects, comparison between them could be less significant. Although the overall mean DII score was not significantly different between obese and non-obese subjects, we found suggestive evidence for a role of anti-inflammatory food parameters like onion and nutrients (vitamin B-6, vitamin A and zinc) to improve the dietary recommendation for prevention and control of obesity and non-communicable diseases in Myanmar population.

ACKNOWLEDGEMENTS

We would like to acknowledge all school teachers who participated in this study. We also would like to thank all directors and all staff from the Yangon Regional Public Health Department, National Nutrition Center and Department of Medical Research and all survey team members for contributing in the whole data collection process. We also would like to acknowledge Dr Ir. Helda Khusun, Dr Saptawati Bardosono, Dr Rina Kusumaratna and Dr Nunik Kusumawardani for giving valuable inputs in proposal development and report writing.

AUTHOR DISCLOSURES

None of the authors had a conflict of interest.

Financial support

Funding source was not involved in the conduct of the study or writing of the manuscript.This study was supported by DAAD scholarship research funding for a Master student.

REFERENCES

1. World Health Orgnization; Overweight and obesity factsheet. World Health Orgnization; 2016. [2016/06/26]; Available from: www.who.int/mediacentre/factsheets/fs311/en/.
2. The World Health Organization; Non communicable diseases risk factors STEP survey Myanmar. [2015/10/17]; Available from: http://www.searo.who.int/entity/noncommunicable_diseases /data/mmr_ncd_reports/en/.pdf.
3. The World Health Orgnization. Noncommunicable Diseases in the South-East Asia Region: Situation and Response; 2011. Regional Office for South-East Asia. India: World Health Orgnization; 2011.
4. Trayhurn P, Wood IS. Adipokines: inflammation and the pleiotropic role of white adipose tissue. Br J Nutr. 2007;92: 347-55. doi: 10.1079/bjn20041213.
5. Rodriguez-Hernandez H, Simental-Mendia LE, Rodriguez-Ramirez G, Reyes-Romero MA. Obesity and inflammation: epidemiology, risk factors, and markers of inflammation. Int J Endocrinol. 2013;2013:678159. doi: 10.1155/2013/678159.
6. Bo S, Durazzo M, Guidi S, Carello M, Sacerdote C, Silli B et al. Dietary magnesium and fiber intakes and inflammatory and metabolic indicators in middle-aged subjects from a population-based cohort. Am J Clin Nutr. 2006;84:1062-9.
7. Wannamethee SG, Lowe GDO, Rumley A, Bruckdorfer KR, Whincup PH. Associations of vitamin C status, fruit and vegetable intakes, and markers of inflammation and hemostasis. Am J Clin Nutr. 2006;83:567-74.
8. Julia C, Meunier N, Touvier M, Ahluwalia N, Sapin V, Papet I et al. Dietary patterns and risk of elevated C-reactive protein concentrations 12 years later. Br J Nutr. 2013;110: 747-54. doi: 10.1017/S0007114512005636.
9. Wood AD, Simpson WG, Gryka AA, Hardcastle AC, Mavroeidi A, Rothnie I, et al. Dietary patterns are associated with biomarkers of chronic low grade systemic inflammation in Scottish postmenopausal women: a prospective analysis. Proc Nutr Soc. 2013;71:E251. doi: 10. 1017/s0029665112003424.
10. Nettleton JA, Steffen LM, Mayer-Davis EJ, Jenny NS, Rui Jiang, Herrington DM, Jacobs DR Jr. Dietary patterns are associated with biochemical markers of inflammation and endothelial activation in the Multi-Ethnic Study of Atherosclerosis (MESA). Am J Clin Nutr. 2006;83:1369-79.
11. Nanri A, Yoshida D, Yamaji T, Mizoue T, Takayanagi Y, Kono S. Dietary patterns and C-reactive protein in Japanese men and women. Am JClin Nutr. 2008;87:1488-96.
12. Lee H, Lee IS, Choue R. Obesity, inflammation and diet. Pediatr Gastroenterol Hepatol Nutr. 2013;16:143-52.doi: 10.5223/pghn.2013.16.3.143.
13. Bullo M, Casas-Agustench P, Amigo-Correig P, Aranceta J, Salas-Salvado J. Inflammation, obesity and comorbidities: the role of diet. Public Health Nutr. 2007;10:1164-72. doi: 10.1017/S1368980007000663.

14. Calder PC, Ahluwalia N, Brouns F, Buetler T, Clement K, Cunningham K et al. Dietary factors and low-grade inflammation in relation to overweight and obesity. Br J Nutr. 2011;106(Suppl 3):S5-78.
15. Shivappa N, Steck SE, Hurley TG, Hussey JR, Hebert JR. Designing and developing a literature-derived, population-based dietary inflammatory index. Public Health Nutr. 2013; 17:1689-96. doi: 10.1017/S1368980013002115.
16. Cavicchia PP, Steck SE, Hurley TG, Hussey JR, Ma Y, Ockene IS, Hebert JR. A new dietary inflammatory index predicts interval changes in serum high-sensitivity C-reactive protein. J Nutr. 2009;139:2365-72. doi: 10.3945/jn. 109.114025.
17. Shivappa N, Steck SE, Hurley TG, Hussey JR, Ma Y, Ockene IS, Tabung F, Hebert JR. A population-based dietary inflammatory index predicts levels of C-reactive protein in the Seasonal Variation of Blood Cholesterol Study (SEASONS). Public Health Nutr. 2013;17:1825-33. doi: 10. 1017/S1368980013002565.
18. Wirth MD, Burch J, Shivappa N, Violanti JM, Burchfiel C, Fekedulegn D et al. Association of a dietary inflammatory index with inflammatory indices and metabolic syndrome among police officers. J Occup Environ Med. 2014;56:986-9. doi: 10.1097/JOM.0000000000000213.
19. Ruiz-Canela M, Zazpe I, Shivappa N, Hebert JR, Sanchez-Tainta A, Corella D et al. Dietary inflammatory index and anthropometric measures of obesity in a population sample at high cardiovascular risk from the PREDIMED (PREvencio´n con DIeta MEDiterra´nea) trial. Br J Nutr. 2015;113:984-95. doi: 10.1017/S0007114514004401.
20. Wirth M, Burch J, Shivappa N, Steck SE, Hurley TJ, Vena JE, Hébert JR. Dietary inflammatory index scores differ by shiftwork status: NHANES 2005–2010. J Occup Environ Med. 2014;56:145-8. doi: 10.1097/JOM.0000000000000088.
21. Galas A, Kulig J. Low-grade dietary-related inflammation and survival after colorectal cancer surgery. J Cancer Res Clin Oncol. 2014;140:1517-25. doi: 10.1007/s00432-014-17 11-6.
22. Zamora-Ros R, Shivappa N, Steck SE, Canzian F, Landi S, Alonso MH, Hebert JR, Moreno V. Dietary inflammatory index and inflammatory gene interactions in relation to colorectal cancer risk in the Bellvitge colorectal cancer case-control study. Genes Nutr. 2015;10:447. doi: 10.1007/s1226 3-014-0447-x.
23. Best Start Resource Centre. Obesity in preconception and pregnancy. Toronto, Ontario, Canada: Health Nexus: 2013
24. Ovesen P, Rasmussen S, Kesmodel U. Effect of prepregnancy maternal overweight and obesity on pregnancy outcome. Obstet Gynecol. 2011;118:305-12. doi: 10.1097/AOG.0b013e3182245d49.
25. Mariammal T, Jaisheeba AA, Sornaraj. R. Work influenced occupational stress and cardiovascular risk among teachers and office workers. J Chem Pharm Res. 2012;4:1807-11.
26. Phyu KP, Maung M, Win LL, Mar KK, Tun ZW, Marlar M, Khaing W, Aye KT, Thant KZ. Prevalence and risk factors of diabetesmellitus among middle-aged school teachers inMandalay City. Myanmar Health Sciences Research Journal. 2010;22:147-50.
27. TANITA. Inner scan Body Composition Monitor Manual. USA: Tanita Cooperation, 2005. BC 541
28. Erhardt JG, Estes JE, Pfeiffer CM, Biesalski HK, Craft NE. Combined measurement of ferritin, soluble transferrin receptor, retinol binding protein, and C-reactive protein by an inexpensive, sensitive, and simple sandwich enzyme-linked immunosorbent assay technique. J Nutr. 2004;134: 3127-32.
29. Schakel SF, Buzzard IM, Gebhardt SE. Procedures for estimating nutrient values for food composition databases. J Food Comp Anal. 1997;10:102-14.
30. WHO Regional Office for the Western Pacific/International Association for the Study of Obesity/International Obesity Task Force. The Asia-Pacific perspective: redefining obesity and its treatment. Sydney: Health Communications Australia; 2000.
31. Wang C, Hou XH, Zhang ML, Bao YQ, Zou YH, Zhong WH, Xiang KS, Jia WP. Comparison of body mass index with body fat percentage in the evaluation of obesity in Chinese. Biomed Environ Sci. 2010;23:173-9.
32. Global Physical Activity Questionnaire (GPAQ). [2015/03/30]; Available from: www.who.int/chp/steps.
33. Gibson RS. Principles of Nutritional Assessment. 2nd ed. New York: Oxford University; 2005. pp. 167-9.
34. Goldberg GR, Black AE, Jebb SA, Cole TJ, Murgatroyd PR, Coward WA, Prentice AM. Critical evaluation of energy intake data using fundamental principles of energy physiology:1. Deviation of cut-off limits to identify under-reporting. Eur J Clin Nutr. 1991;45:569-81.
35. Shivappa N, Hebert JR, Rietzschel ER, Buyzere MLD, Langlois M, Marcos A, Huybrechts A. Associations between dietary inflammatory index and inflammatory markers in the Asklepios Study. Br J Nutr. 2015;113:665-71. doi: 10.1017/ S000711451400395X.
36. Barba CVC, Cabrera MIZ. Recommended dietary allowances harmonization in Southeast Asia. Asia Pac J Clin Nutr. 2008;17:405-8.
37. Tint HS, Oung MT, Htet KKK, Win ZC, Zin KH, Thwe AH. Prevalence and correlation of obesity, hypertension and diabetes mellitus in selected township of upper Myanmar. Myanmar Health Science Research Journal. 2011;23:178-85.