

## Dietary Patterns and Its Associations with Adipokines (Adiponectin and Leptin) among Adults: A Narrative Review

(Corak Pemakanan dan Kaitannya dengan Adipokin (Adiponektin dan Leptin)  
dalam Kalangan Dewasa: Sebuah Ulasan Naratif)

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### ABSTRACT

*To compile and analyse existing scientific evidence regarding the association of dietary patterns with adiponectin and leptin. Medline and PubMed electronic databases were searched for articles related to the association of dietary patterns with adiponectin and leptin from 2005 to 2015. Only full text articles using English as a language of publication were included. Studies were limited to the use of food frequency questionnaires in assessing dietary intake, factor analysis using principal component analysis, cluster analysis or reduced rank regression method in determining dietary pattern. A total of six relevant studies involving a total of 6467 subjects (47% men and 53% women) met the inclusion criteria from 1407 reviewed articles. Twelve dietary patterns were extracted i.e. healthy pattern, meat and fat, sweet pattern, potatoes and refined grains, Japanese pattern, westernized pattern, mixed pattern, traditional pattern, vegetables, fruits and lean meat pattern, high alcohol, 'Izakaya' pattern and dieting. Two studies showed association with leptin which serum leptin concentration showed significantly higher in vegetables, fruits and lean meat compared to western pattern and lower circulating levels of leptin in westernized breakfast dietary pattern. Adiponectin concentration resulting significant positive relationship with fruits and vegetables, dieting, Japanese and healthy dietary pattern. Adherence to healthy dietary patterns plays an important role on serum adiponectin and leptin concentration. However, in most studies that resulted in a significant relationship, adiponectin, leptin and diet components were evaluated separately. Therefore, further well-designed studies were required to clarify the mechanism mediating relationship between dietary patterns and adipokines.*

**Keywords:** Adiponectin; adult; dietary pattern; food-frequency questionnaires; factor analysis; leptin; principal component analysis

### ABSTRAK

*Mengumpul dan menganalisis data kajian saintifik yang sedia ada mengenai perkaitan di antara corak pemakanan dengan adiponektin dan leptin. Pangkalan data elektronik Medline dan PubMed telah digunakan untuk mencari artikel mengenai perkaitan corak pemakanan dengan adiponektin dan leptin dari tahun 2005 hingga 2015. Hanya artikel teks penuh dan yang menggunakan bahasa Inggeris sebagai bahasa penerbitan diterima. Kajian telah terhad kepada penggunaan soal selidik kekerapan pengambilan makanan dalam menilai pengambilan makanan manakala dalam menentukan corak pemakanan kaedah yang digunakan haruslah faktor analisis, analisis komponen utama, analisis kelompok atau pengurangan kaedah regresi pangkat. Sebanyak enam kajian yang relevan dan memenuhi kriteria dari 1407 artikel yang telah dipilih. Kajian terpilih tersebut melibatkan seramai 6467 orang subjek (53% wanita dan 47% lelaki). Dua belas corak pemakanan yang dikaji ialah pemakanan sihat, daging dan lemak, gula dan manisan, kentang dan bijirin halus, pemakanan Jepun, pemakanan barat, pemakanan pelbagai, pemakanan tradisional, sayur-sayuran, buah-buahan dan corak pemakanan daging tanpa lemak, alkohol yang tinggi, dan diet 'Izakaya'. Dua kajian menunjukkan perkaitan dengan leptin dimana kepekatan serum leptin adalah jauh lebih tinggi dengan pengambilan corak pemakanan sayur-sayuran, buah-buahan dan daging tanpa lemak berbanding corak pemakanan barat. Kepekatan leptin dalam serum adalah lebih rendah pada pengambilan sarapan makanan barat. Manakala, kepekatan adiponektin menunjukkan perkaitan positif yang signifikan dengan pengambilan corak pemakanan tinggi buah buahan dan sayuran, corak pemakanan Jepun dan pemakanan sihat. Amalan corak pemakanan yang sihat memainkan peranan penting dalam mengawal kepekatan adiponektin dan leptin dalam serum. Walau bagaimanapun, dalam kebanyakan kajian yang menunjukkan hubungan yang signifikan bagi adiponektin dan leptin, komponen dietnya telah dinilai secara berasingan. Oleh itu, kajian yang lebih lanjut perlu dilakukan untuk menjelaskan hubungan mekanisme di antara corak pemakanan dan adipokin.*

**Kata kunci:** Adiponektin; analisis komponen utama; corak pemakanan; dewasa; faktor analisis; leptin; soal selidik kekerapan pengambilan makanan

## INTRODUCTION

Adipokines is a generic term for >50 metabolically active factors which are expressed and secreted by an active endocrine organ – adipose tissue (Rokling-Andersen et al. 2007). Leptin, adiponectin, visfatin and tumour necrosis factor- $\alpha$  are among a wide range of adipokines that responsible for majority of endocrine, metabolic and vascular disorder related to obesity and obesity mediated adverse effects on glucose and lipid metabolism (Jafari-Vayghan et al. 2015; Monzillo et al. 2003) adiponectin, resistin, tumor necrosis factor-alpha (TNF-alpha). Leptin concentration has been associated with a higher risk of type 2 diabetes, hypertension and chronic heart disease (Kashino et al. 2015). According to Jafari-Vayghan et al. (2015) the role in the regulation of food intake and energy expenditure is exerted by the leptin. Theoretically, adipose tissue will increase in mass and leads to obesity whenever energy intake exceeds the expenditure and a high serum leptin concentration detected in some obese subjects were related to leptin resistance. These are explained by the failure or decrease in leptin transport to the central nervous system of leptin receptors (Kopelman & Grace 2004). Moreover, in hunger or fasting states, the concentration of leptin decreases. Hence, according to study done by Klok et al. (2007) on the role of leptin in the regulation of food intake, diet plays a direct and indirect role in the circulatory leptin concentration.

However, although adiponectin is also secreted from adipocytes, unlike leptin, its concentration is negatively correlated with body fat mass (Izadi & Azadbakht 2015). Adiponectin has the anti-obesity, anti-diabetic, anti-cancer, anti-inflammation properties and a high concentration of serum adiponectin was also shown to be associated with insulin sensitivity (Izadi et al. 2012; Evagelidou et al. 2007; Izadi & Azadbakht 2015). Besides similar to leptin, lifestyle-related factors such as physical activity and diet play a significant role in adiponectin concentration. Therefore, as adipokines; leptin and adiponectin are presumed to be biochemical predictors of many chronic non-communicable diseases such as diabetes, hypertension and coronary heart disease, it is crucial to discover modifiable factors including the pattern of diet that have an effect on these adipokines (Kashino et al. 2015).

Diet is a wide variety of foods containing complex combinations of nutrients and people consume a complex combination of food items. In nutrition epidemiology, the difficulties when searching for the impact of single nutrients have stimulated researcher's awareness to investigate the health effect of food item combinations that is food or dietary patterns (Barbaresko et al. 2013; Lucas et al. 2014; Martinez-Gonzalez & Bes-Rastrollo 2014). Dietary pattern is among the important factors in the promotion and maintenance of good health throughout the entire course of life (Marchini et al. 2005). The analysis of dietary pattern has been implicated as an approach to examine diet-diseases relationship as it represents a broader picture of food and nutrient consumption and may thus be

more predictive of diseases risk than individual food or nutrient (Shang et al. 2012). According to De Caterina et al. (2006), considerable evidence has accumulated that the dietary factors are the cornerstone in the prevention and treatment of lifestyle-related illness.

Adherence to healthy dietary pattern such as Mediterranean dietary pattern, fruits and vegetables dietary pattern and soy based dietary pattern previously displayed key role on protection against metabolic diseases, reduced risk of breast cancer and hip fracture (Catsburg et al. 2015; Dai et al. 2014; Mantzoros et al. 2006). In addition, based on Izadi and Azadbakht (2015) an increase in adiponectin or decrease in leptin concentration could be a mediator in differentiating between different types of dietary pattern. The present review aimed to gather available findings on the relationship between dietary pattern and adipokines i.e. adiponectin and leptin concentration among adults.

## METHODS

### LITERATURE SEARCH

Computerized databases of Medline and PubMed were used to conduct a literature search for scientific English articles published from 2005 to 2015. The search was initiated using various combinations of keywords and terms related to dietary pattern, adiponectin and leptin as follows: 'diet' OR 'diet quality' OR 'dietary pattern' OR 'food pattern' OR 'eating pattern' OR 'food habits' OR 'food preferences' AND 'adiponectin', OR 'AdipoQ', OR 'ACRP30', OR 'apM-1' OR 'leptin', OR 'Ob Protein'.

### INCLUSION AND EXCLUSION CRITERIA

Included articles must be measuring the association of dietary pattern and serum adiponectin or leptin concentrations among human adults subjects (>18 years old). Studies that only examined relationship on special dietary components such as omega 3 fatty acid or high fat with serum leptin or adiponectin concentration instead of dietary pattern analysis were excluded. The eligible articles must be in English language, full-length and published in peer reviewed journals. Moreover, to be included in the present study, dietary intake must be obtained through food frequency questionnaires instead of other traditional methods such as 24 h diet recall or food record. Apart from that, studies that did not apply factor analysis specifically principal component analysis, cluster analysis, or reduced rank regression to identify dietary pattern were excluded.

### DATA EXTRACTION AND ANALYSIS

Data were extracted for analysis of the methodology and outcomes from each study. The titles and abstracts of the identified articles were screened to eliminate duplicates and unrelated articles. Studies, which met the inclusion criteria were chosen and full-text was checked to determine articles for the final selection. Figure 1 explains the flow of literature search process.

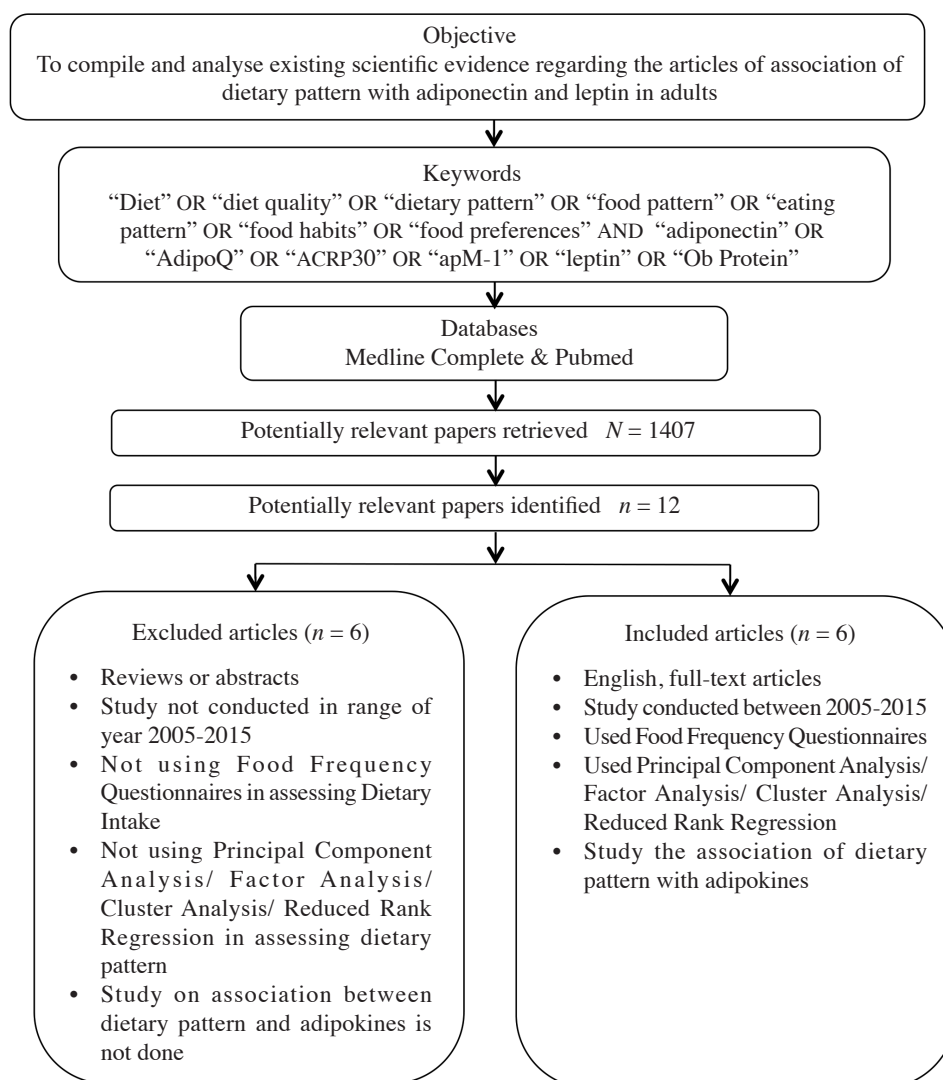


FIGURE 1. The flow in the literature search process

## RESULTS

### ARTICLES RETRIEVED

A total of 1407 articles were reviewed according to the inclusion and exclusion criteria (Figure 1). Most articles were excluded due to lack of direct relation with the aim of this review; for example articles that not really assessing the relationship between dietary pattern with adiponectin or leptin and articles that only showing relationship on specific dietary components such as omega-3 fatty acids or high fat intake with adipokines concentration. Finally, a total of six relevant studies met the inclusion criteria which the association between dietary pattern and serum adipokines among adults were assessed throughout the study.

### SOCIO-DEMOGRAPHIC CHARACTERISTICS

Socio-demographic characteristics of the respondents were summarized in Table 1. The present review includes a total

of 6467 subjects involving 47% men and 53% women with majority representing non-institutionalized US civilian. All subjects were from 20 to 80 years of age and most have good health status with no illness except 2% of total subject who were patients with metabolic syndrome according to the National Cholesterol Education Program's Adult Treatment Panel III report (NCEP ATP III) criteria.

### RELATIONSHIP OF DIETARY PATTERN WITH ADIPOKINES (ADIPONECTIN AND LEPTIN)

Table 2 presents the association of dietary pattern with serum adiponectin and leptin among six eligible articles. There were several types of dietary pattern category shown by all six studies including vegetables, fruit and lean meat, high alcohol, dieting, traditional Japanese, western, traditional English, sweet-fruit, 'Izakaya' (Japanese pub), westernized breakfast, mixed and healthy patterns. A positive correlation of adiponectin with fruit and vegetables, dieting, healthy and traditional Japanese dietary pattern was observed. However, negative association

TABLE 1. Socio-demographic characteristics of the respondents enrolled in eligible articles ( $n=6$ )

No.	Author (Year)	Country	Mean Age $\pm$ SD [Range]	Gender = Numbers	Sample
1.	Ganji et al. (2009)	USA	43.4 $\pm$ 0.9	Men = 1907 Women = 2102	Data from the third National Health and Nutrition Examination Survey, 1988-1994; a sample representative of the US civilian, non-institutionalized population
2.	Cassidy et al. (2009)	UK	47.8 $\pm$ 12.3 [18 – 80]	Women = 877	Twins UK adult twin registry which were a sample of the total population group who attended for dual-energy x-ray absorptiometry scans and clinical assessment between 1996 and 2000
3.	Guo et al. (2012)	Japan	44.5 [37.8 – 54.2]	Men = 702	Subjects who had received lifestyle related illness and health examinations (including a blood examination) at Sendai Oroshisho Centre in 2008
4.	Kashino et al. (2015)	Japan	43.4 $\pm$ 10.7 [20 – 65]	Men = 296 Women = 213	Healthy full-time employees of two municipal offices in north eastern Kyushu, Japan
5.	Jafari-Vayghan et al. (2015)	Iran	36.7 $\pm$ 8.8 [25 – 50]	Men = 75 Women = 75	Healthy subject randomly selected from a larger study of 670 apparently healthy subject that aimed to identify dietary patterns in Tabriz, Iran
6.	Farhangi et al. (2015)	Iran	43.1 $\pm$ 10.3 [ $>$ 20]	Men = 23 Women = 134	Patients who have metabolic syndrome according to the National Cholesterol Education Program's Adult Treatment Panel III report (NCEP ATP III) criteria

was shown between adiponectin and traditional English, 'Izakaya' and western dietary pattern. Meanwhile, the concentration of leptin was increased with higher scores of vegetables, fruits, lean meat, mixed dietary pattern and decreased when consuming a westernized breakfast dietary pattern. Other types of dietary pattern including high alcohol and sweet-fruit pattern have no association with adiponectin and leptin concentration in the reviewed studies. The physiological relationship between dietary pattern, adipose tissue and adipokines (adiponectin and leptin) level summarized from all six studies included in this review is presented in Figure 2. The healthier choice of dietary pattern, e.g. fruits and vegetables, dieting, healthy, traditional Japanese and westernized breakfast might reduce adiposity which would increase adiponectin levels and at the same time lower the production of leptin, glucose and insulin level.

#### DISCUSSION

Regularly, the effects of single nutrients or foods have been focused in nutritional epidemiology studies. However, people consume a complex combination of food items that contains a variety of nutrients (Fung et al. 2001) little attention has been given to the effect of overall dietary patterns. Objective: Our objective was to examine the associations of 2 major dietary patterns, Western and prudent, with biomarkers of obesity and cardiovascular disease (CVD). Therefore, food and nutrient combination, interactions, inter-correlations and cumulative effects have to be used as an alternative approach to study overall diet instead of single dietary components. Apart from that, the

use of dietary pattern analysis is important because the focus of the analysis is on the entire diet, rather than on just one food or nutrient and offers an additional dimension to examine the relationship between diet and disease risk (Frank et al. 2015) but has not been applied in sub-Saharan Africa. In a hospital-based case-control study for type 2 diabetes in Kumasi (diabetes cases, 538; controls, 668). According to Kashino et al. (2015) diet have been identified as one of the modifiable factors that may affect adipokines such as adiponectin and leptin which are the important biochemical indices that might have a role in health and disease. Hence, it is important to see the association of adiponectin and leptin concentration with different types of dietary patterns. Most evidence from eligible studies suggest a significant positive relationship between healthy dietary pattern such as fruits and vegetables pattern, Japanese pattern and dieting pattern with the concentration of adiponectin whereas high consumption of western dietary pattern lowers serum leptin concentration.

The present review involved studies from both western and Asian countries. Most sample were from western countries with 63% from non-institutionalized US civilian and 14% from TwinsUK adult registry. Whereas, Asian countries were represented by 11% who had received lifestyle related illness and health examination at Sendai Oroshisho Centre and another 8% from healthy full-time employee of two municipal offices in north eastern Kyushu, Japan. Apart from that, the remaining two studies were carried out at western Asia countries, involving 150 healthy subjects randomly selected from a larger study that aimed to identify dietary pattern in Tabriz, Iran and 157 patients who have metabolic syndrome according to the National

TABLE 2. Association of dietary pattern with adipokines; serum adiponectin and leptin concentration ( $n=6$ )

Author (Year)	Aims/Purposes	Dietary intake method	Dietary pattern category	Adiponectin measurement site/assay/CV (%)	Leptin measurement site/assay/CV (%)	Adjusted variables	Finding(s)	Comment (s)
Ganji et al. (2009)	To investigate the relation between serum leptin concentrations and dietary patterns and demographic, lifestyle, and health in the US population	Interviewer-administered 80-items qualitative FFQ	<ul style="list-style-type: none"> <li>Vegetables, fruits and lean meat pattern</li> <li>Western dietary pattern</li> <li>Mixed pattern</li> </ul>	NA	Serum/ ELISA/ 3.4% to 8.3%	<ul style="list-style-type: none"> <li>Sex, race-ethnicity, smoking, age, energy intake, alcohol intake and BMI</li> </ul>	<ul style="list-style-type: none"> <li>Significantly higher serum leptin concentration in vegetables, fruits, and lean meat and mixed pattern compared to western pattern</li> <li>No significant association observed between serum leptin and dietary pattern (<math>p=0.22</math>) when analysis was adjusted for confounding variables</li> </ul>	<ul style="list-style-type: none"> <li>Negative significant finding of leptin with fruits, vegetables and lean meat pattern suggest that these combination of dietary pattern might give risk to health status with increasing the leptin concentration</li> </ul>
Cassidy et al. (2009)	To examine the associations of body composition, dietary patterns, foods and nutrients on adiponectin concentration in female twins	131-item validated FFQ	<ul style="list-style-type: none"> <li>Fruits and vegetables (F&amp;V)</li> <li>High alcohol</li> <li>Traditional English</li> <li>Dieting</li> <li>Low meat</li> </ul>	Plasma/ DELFIA/ 9.9%	NA	<ul style="list-style-type: none"> <li>Age, BMI, energy intake, PA, smoking and social class</li> </ul>	<ul style="list-style-type: none"> <li>Significant positive relationship for both fruits and vegetables pattern and dieting pattern with plasma adiponectin</li> <li>Negative associations between traditional English pattern and plasma adiponectin following multivariable adjustment</li> </ul>	<ul style="list-style-type: none"> <li>Studied had only done towards female twins and significant finding cannot represent the total population as had gender bias</li> </ul>
Guo et al. (2012)	To evaluate whether dietary patterns are associated with serum adiponectin concentration in Japanese adult men	Self-administered diet history questionnaires (BDHQ) that included questions on 75 food items	<ul style="list-style-type: none"> <li>Traditional Japanese pattern</li> <li>Sweet-fruit pattern</li> <li>'Izakaya' pattern</li> </ul>	Serum/ Specific Sandwich enzyme-linked immunosorbent assay/ <10%	NA	<ul style="list-style-type: none"> <li>Age, BMI, PA, smoking status, depressive symptoms, sleep duration, education level &amp; occupation</li> </ul>	<ul style="list-style-type: none"> <li>There was a significant positive correlation of adiponectin and 'Japanese' dietary pattern (<math>p&lt;0.01</math>)</li> <li>Significant inverse association was found between 'Izakaya' pattern and adiponectin (<math>p</math> for trends = 0.03)</li> <li>No relationship between 'sweet-fruit' pattern score and adiponectin</li> </ul>	<ul style="list-style-type: none"> <li>Although 'Izakaya' food pattern resulting in inverse association with adiponectin but some food component under its pattern such as fish, fermented soybeans showed positive significant with adiponectin proved that further study required to clarify the relationship of the pattern type with adipokines</li> </ul>

(continued)

TABLE 2 (cont.)

Author (Year)	Aims/Purposes	Dietary intake method	Dietary pattern category	Adiponectin measurement site/ assay/CV (%)	Leptin measurement site/assay/CV (%)	Adjusted variables	Finding(s)	Comment (s)
Farhang et al. (2015)	To investigate relationship between major dietary patterns and cardio-metabolic risk factors in patients with metabolic syndrome	147-items semi-quantitative standard FFQ	<ul style="list-style-type: none"> <li>• Healthy pattern</li> <li>• Meat &amp; fat pattern</li> <li>• Sweet pattern</li> <li>• Potatoes &amp; refined grains pattern</li> </ul>	Plasma/ ELISA/ Inter assay CV of <12% and Intra assay CV of <10%	NA	Age, BMI, family history of diabetes and educational attainment	Higher healthy pattern score was in relation significantly with higher concentration of adiponectin	Studies had found independent association between dietary pattern and blood pressure and serum lipids which further supporting the protective effect of healthy diet with fruits, vegetables and fish as predominant food items
Kashino et al. (2015)	To investigate association between major dietary pattern and circulating concentrations of adiponectin, leptin, resistin, visfatin and plasminogen activator inhibitor-1 (PAI-1) in a working population	Brief self-administered diet history questionnaire (BDHQ) for 58 food and beverage item	<ul style="list-style-type: none"> <li>• Japanese pattern</li> <li>• Westernized breakfast pattern</li> <li>• Meat food pattern</li> </ul>	Serum/ Luminex suspension bead-based multiplexed array intra-assay CV 12%	Serum/ Luminex suspension bead-based multiplexed array intra-assay CV 11%	Age, sex, workplace, marital status, BMI, occupational physical activity, non-occupational physical activity, smoking and total energy intake	Leptin concentration decreased with increasing scores of westernized breakfast pattern ( $p$ for trend = 0.04)	No association shown between most dietary patterns with adipokines might be because of low validity for some food items in the dietary pattern groups
Jafari-Vayghan et al. (2015)	To investigate the association between various dietary patterns and L/A ratio in Iranian adults	Interviewer-administered 132-item semi-quantitative FFQ on 5-point scale	<ul style="list-style-type: none"> <li>• Western pattern</li> <li>• Healthy pattern</li> <li>• Mix pattern</li> <li>• Traditional pattern</li> </ul>	Serum/ Sandwich enzyme-linked immune-sorbent assay	Serum/ Sandwich enzyme-linked immune-sorbent assay	Age, sex, BMI and WC	Negative association between western dietary pattern and adiponectin concentration	Physical activity might influence serum adiponectin and leptin concentration and this factor was not assessed during the study

NA = Not available

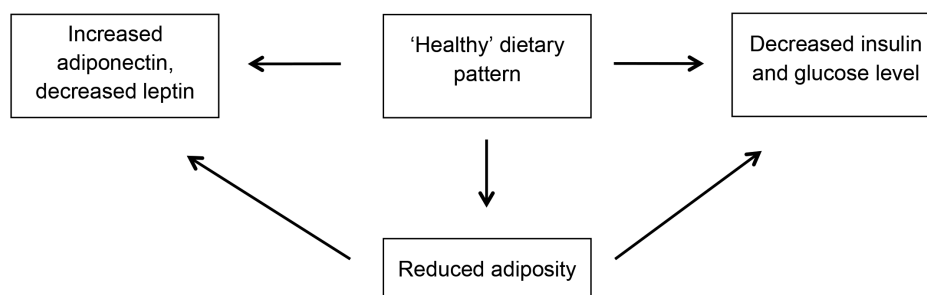


FIGURE 2. Relationship between 'healthy' dietary pattern, adipose tissue and adipokines (adiponectin and leptin)

Cholesterol Education Program's Adult Treatment Panel III. These 157 patients were the only unhealthy subject that involved in the present review. Therefore, even there were small numbers of eligible studies on the relationship of dietary pattern and serum adipokines concentration in these present review, but this review could represent global population as it involves both Asian and western residents.

This review shows that there are significant positive association between fruit and vegetable pattern, dieting pattern and Japanese pattern with adiponectin. Fruit and vegetable pattern is characterized by frequent consumption of fruit, allium and cruciferous vegetables and low intake of fried potatoes. Whereas those practicing dieting pattern frequently consumed low-fat dairy products, low-sugar soda and low intake of butter and sweet baked product. The same goes to Japanese pattern where it shows high consumption of vegetables, soybean, fish and green tea. However, mechanism underlying this relationship which either these components play the vital role on changes of adiponectin or the overall diet that exactly have the beneficial role on this effects are still unknown. Several studies had proved that high fruit and vegetable consumption have been allied with decreased occurrence and mortality from a variety of obesity-related diseases including Type 2 diabetes and cardiovascular diseases (Dauchet et al. 2004; Mozaffarian et al. 2004). Izadi and Azadbakht (2015) found several studies that have assessed the association between Mediterranean dietary pattern and adiponectin which characterized by consumption of high amount of whole grains, olive oil as well as moderate intake of fish and dairy products and lower consumptions of red meat, sweets and saturated fatty acids. These components had characterised Mediterranean diet as a low calorie diet with high amount of fibres, unsaturated fats and low glycaemic load. Their result showed that Mediterranean diet has beneficial effects on circulating of adiponectin. Moreover, previous study found that dietary pattern characterized by a high consumption of whole grains cereals and low fat dairy products was positively associated with adiponectin (Fargnoli et al. 2008; Tsukinoki et al. 2005).

The present review also showed several association of dietary pattern with leptin concentration. One of the study

showed that serum leptin concentrations were significantly lower among individual who consumed western diet compared to those who consumed vegetables, fruits, lean meat and mixed pattern diet (Ganji et al. 2009). This was consistent with findings by Kashino et al. (2015) which showed that westernized breakfast dietary pattern had lower circulating concentrations of leptin. The present review also showed that westernized breakfast pattern had high scores for confectioneries, bread, milk and yogurt but lower scores for alcoholic beverages and rice. This might be explained by foods and nutrients that contributed to the westernized breakfast pattern. Interestingly Akter et al. (2012) found a negative association between westernized breakfast pattern with prevalence of metabolic syndrome and high blood pressure which indicates westernized breakfast pattern might decrease risks of metabolic disease by reducing circulating leptin concentration.

#### LIMITATIONS

The main drawback of this review was the limited number of included articles. Our inclusion criteria indicated the use of food frequency questionnaires in dietary intake assessment and factor analysis, principal component analysis, cluster analysis or reduced rank regression analysis in detecting dietary pattern and its scores. In addition, most available studies have instead looked into association of adipokines with single food or nutrients rather than dietary pattern. These were the most crucial criterion that limit the number of eligible articles in the present narrative review. It was also noteworthy that the narrative method chosen to conduct this review has its own limitation where the systematic process of rating and selecting manuscript were not followed. Although the current review process includes specific inclusion and exclusion criteria for studies to be reviewed, selection bias is always possible due to the subjective nature of the narrative.

#### CONCLUSION

This review suggested that healthy dietary pattern characterized by high consumption of fruit and vegetables, low-fat dairy products, low-sugar soda and low intake of butter and sweet baked product such as dieting pattern

and Japanese dietary pattern plays an important role in increasing serum adiponectin concentration. Whereas, leptin concentration decreased with increasing scores of westernized breakfast pattern. However, in most studies, the relationship of dietary pattern with adiponectin and leptin had evaluated diet components separately and the mechanisms underlying the association were not explained. Therefore, further well-designed studies were required to clarify the mechanism mediating relationship between dietary patterns and adipokines.

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