
The Association Between Dietary Patterns and Insulin Resistance: A Systematic Review

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Abstract: *Background:* Insulin resistance (IR) is associated with multiple metabolic disorders, increasing thereby the risk of type 2 diabetes. The systematic review was performed to study the association between dietary patterns and insulin resistance. *Method:* The study was carried out in database of PubMed, Scopus, Iran Medex and Magiran for the main keywords including diet, insulin, insulin resistance, dietary pattern. *Finding:* Articles used collected for review were publications until March 2015. Prospective cohort studies and cross sectional studies were selected based on their title, abstract and full text of the materials. After excluding experimental surveys and studies focused on children and randomized clinical trials, required information were extracted. The results show that “Western” dietary patterns rich in red meat, fried and processed dishes, refined cereals and carbohydrate with high glycemic index has statistically significant effects in incidence of insulin resistance. *Conclusion:* The results of this systematic review indicate that unhealthy food habits rich in trans fatty acids and saturated fatty acids, refined carbohydrate with high glycemic index are related to the insulin resistance, hyperglycemia and risk of type 2 diabetes.

Keywords: Diet, Insulin, Insulin Resistance, Dietary Pattern

1. Introduction

Insulin resistance (IR) is a patho-physiological condition where the insulin reporter is less sensitive and therefore insulin in a natural dose is not enough to produce normal biological effects. Insulin resistance is a major risk factor for the development of type 2 diabetes, cardiovascular disease and metabolic syndrome [1].

In the USA, the National Health and Nutrition Examination Survey found that 52.1% obese adolescents had IR [2]. The obesity-associated increase in fatty acids can trigger insulin resistance through intracellular metabolites that activate protein kinases C (PKC), leading to the activation of serine/threonine kinases that inhibit insulin signaling [3]. Diet seems to play an important role in IR. Nowadays, various aspects of diet, such as fat, carbohydrate, fiber, whole grain and glycemic index and glycemic load have been related to IR [2]. Traditionally, nutritional epidemiology has

examined the relationship between diet and disease by evaluating the effects of single nutrient or specific foods [4]. However in daily life, people consume a variety of foods with complex combinations of nutrients. To carry out nutritional epidemiological research with more closely models on human experience, researchers have proposed studying dietary patterns rather than isolated foods. This approach can help us to more accurately understand the links between food consumption and the spread or prevention of chronic disease [1].

Therefore, the aim of this review is to study of the association between dietary pattern and insulin resistance.

2. Material and Methods

2.1. Search Strategy

This paper reviews the articles including cohort and cross sectional studies that published until 2015 in all journals,

using scientific database, including PubMed, Scopus, Iran Medex and Magiran, using keywords which included: insulin, insulin resistance, dietary pattern, diet and other related key words.

2.2. Inclusion and Exclusion Criteria

All studies were selected based on their title, abstract and full text of the materials. The experimental and children studies, case control, clinical trial and duplicate article were excluded. Information obtained from different studies (Table 1) is based on following item respectively: a authors, country, sex, age, sample size, follow up period, dietary intake assess, dietary pattern, result and adjustment variable and primary results of data base search revealed over390 papers in pubmed regarding insulin resistance and dietary pattern. From 2749 articles in scientific data bases, there were 1087on the subject of diets and insulin resistance. After comprehensive review of title, abstracts and the main objectives of studies 12 article were included in this study (Fig. 1).

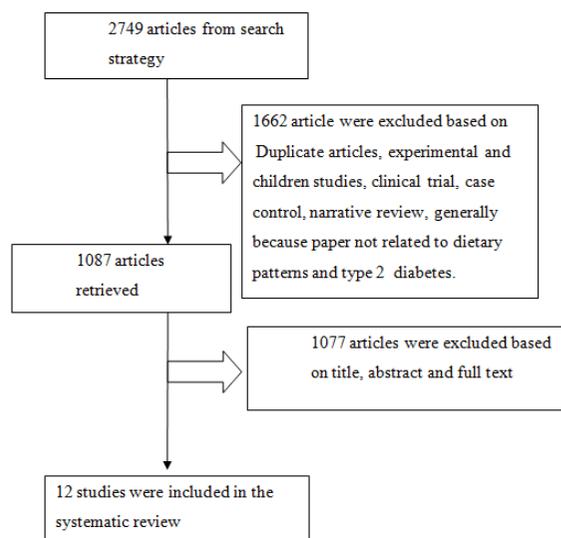


Figure 1. Flow chart of the study.

Table 1. Description of studies of dietary patterns identified via the systematic review.

Author	Country (year)	Sex	Age (year)	Sample size	Follow up period	Dietary intake assess	Dietary pattern	Result	adjustment variable
Arisawa et al 2014	Japan (2008)	Male and females	35-70	513	Cross-sectional	FFQ	PrudentHigh fat/westernBread and dairy productsSeafood	High fat/western dietary pattern was positively correlated with insulin resistance in Japanese population.	Age, sex, smoking, drinking, physical activity, total energy intake
Batis et al., 2014	China (2009)	Male and females	27-68	4096	15 years	24- hour recalls,Hou sehord food inventory	High in wheatproducts and soy milk and low in rice, legumes, poultry, eggs, and fish	Dietary pattern trajectories with healthier scores Longitudinally had a lower HbA1c compared to those with unhealthier scores. Mediterranean-style diet, reflected by a higher <i>a priori</i> Mediterranean diet score, was cross-sectional associated with lower insulin levels among non-diabetics,and lower blood glucose prior to adjustment for obesity, but not with lower incidence ofDiabetes.	Age, sex, geographic city, physical activity, BMI smoking
Abiemo et al., 2013	USA (2000)	Male and females	45-84	5390	Cross-sectional 6 yr follow up	FFQ 127 items	Mediterraneandiet		Age, sex, smoking, physical activity, family income, education level, race, waist circumference
Zuo et al., 2013	China (2006)	Male and females	>18	1070	Open ongoing cohort from 2006	Semi-quantitativ eFFQ	WesternHigh wheat, Traditional,Hedonic	Dietary pattern were significantly associated with insulin resistance	Age, sex, BMI, smoking, physical activity, total energy
Song et al., 2012	South Korea (2007)	Male and females	30-65	3871	1 year	FFQ	Diverse diet, western diet, whole grain and beans,white rice and kimchi,alcohol and coffee	Whole grains and beans patterns were inversely associated with insulin resistance.	Age, sex, education, income, BMI, smoking, alcohol use, physical activity
McNaught on et al., 2008	UK (1988)	Male and females	35-55 items	7339	19 years	127 item FFQ	low calorie/diet soft drinks, onions, sugar-sweetened beverages, burgers and sausages, crisps andother snacks, and white bread and low consumption of medium-/high-fiber breakfast cereals,jam,	Dietary pattern associated with insulin resistance	Age, sex, energy, ethnicity, employment grade, smoking, alcohol, physical activity, BMI, blood pressure

Author	Country (year)	Sex	Age (year)	Sample size	Follow up period	Dietary intake assess	Dietary pattern	Result	adjustment variable
Lie et al, 2009	USA	Male and females		2875		FFQ 126 items	French dressing/vinaigrette, and whole meal bread FruitsReduce fat dairy and whole grainsRefined grains and sweetsBeer and soda	consumption of a diet rich in fruits, vegetables, whole grains and reduced fatdairy protects against insulin-resistant phenotypes and displacing these healthy choices with refined grains, high-fat dairy, sweet bakedfoods, candy and sugar-sweetened soda may promote insulin-resistant phenotypes.	Age, sex, total energy
Esmailzadeh et al	Iran (2007)	Females teachers	40-60	486	Cross-sectional	Semi-quantitative FFQ 168 item	Western Healthy Traditional	High consumption of fruit, vegetables and legumes is associated with reduce risk of insulin resistance and metabolic syndrome in tehrani female teachers.	Age, anthropometry, physical activity, total energy, smoking, current estrogen use and menopausal status
Isharwal et al (2008)	India 2008	Male and females	18>18	352		24-hour food recall		For prevention and amelioration of insulin resistance in Asian Indian adolescents and young adults, it is prudent to have normal BMI and low intake of ω -6 PUFAs.	Sex, BMI, total fat
Desmond E. M. 2000	UK 2000	Male and females	40-65	802	Cross-sectional	35 item FFQ	healthy balanced dietlow intake of fried foods	A prudent diet may be associated with enhanced insulin sensitivity and a lower risk of type 2 diabetes	Sex, age, Socio-economic group, BMI, Smoking status, Alcohol intake category
Villegas r 2004	Irish	Meal and females	adults	1473	Cross sectional	FFQ	Traditional Irish dietPrudent diet Alcohol and convenience food	Adherence to Mediterranean diet is modestly associated with a better	Sex, age, smoking status
Tzima n 2007	Athens	Meal and female	20-87	3042	cohort	FFQ	Mediterranean diet	insulin sensitivity, lower levels of total cholesterol and lower levels of systolic blood pressure in Overweight and obese subjects. This may	Sex, age, BMI, current smoking, physical activity, waist, waist to hip

3. Results and Discussion

In study by Arisawa et al, 513 subjects without treatment for diabetes participated in the baseline survey of cohort study in Tokushima, Japan. Four dietary patterns extracted were: 1- prudent diet (high intake of vegetables and fruits), 2- high fat/western (high intake of fried food, fried dish and meat), 3- bread and dairy products, 4- seafood patterns. Statistical analysis showed that a high fat/western dietary patterns may be positively associated with insulin resistance in the Japanese population [2].

In another study of 4096 adults by Batis et al, with three to six waves of diet data and biomarkers measured in the China health and nutrition surveys, diet was assessed with three 24-hour recalls and a household food inventory. A dietary pattern previously identified with reduced rank regression that positively predicted diabetes in 2006 (high in wheat products and soy milk and low in rice, legumes, poultry, eggs, and fish). Findings suggest that dietary pattern trajectories with healthier scores longitudinally had a lower HbA1c compared to those with unhealthier scores, even when trajectories had similar scores in the end point [5]. Abiemo et al, studied 5390 men and women age, 45-48 years with 6 years follow up in

MESA; dietary intake was assessed as FFQ. A MeDiet score was created based on intake of 10 food components, vegetables, whole grains, nuts, legumes, fruits, ratio of monounsaturated to saturated fat, red and processed meat, dairy, fish and alcohol. MeDiet was not significantly related to risk of incident diabetes. Greater consistency with a Mediterranean-style diet, reflected by a higher *a priori* Mediterranean diet score, was cross-sectionally associated with lower insulin levels among non-diabetics, and lower blood glucose prior to adjustment for obesity, but not with lower incidence of diabetes [6]. Zuo et al, studied 1070 men and women, aged >18 years who participated in the 2006 phase of the China health and nutrition survey. Dietary intake assessed using a validated FFQ and four dietary patterns were identified: the Western (characterized by animal food, milk, cake, etc), high wheat (high in wheat instead of rice, wholegrain and beef/lamb), traditional (high in eggs, tofu, organ meat, pickled, vegetables, etc) and the hedonic pattern (high in beer, wine and alcohols and fresh vegetables). Statistical analysis showed that western pattern was associated with greater odds of insulinresistant; in contrast, the Hedonic pattern was negatively associated with insulin resistance in Chinese adults [1]. In the Song et al, 3871 men and women 30 - 65 years participated in the Korea National Health and Nutrition Examination Survey, using dietary intake to assess was a validated FFQ, and 5 dietary patterns were identified: Diverse diet, western diet, whole grain and beans, white rice and kimchi (traditional fermented cabbage), alcohol and coffee. A dietary pattern, characterized by high consumption of whole grains, beans and fruits was found to inversely associated with insulin resistance in healthy Korean adults [7]. McNaughton et al, assessed 7,339 participants of the Whitehall II study, measuring dietary intake using a 127-item food frequency questionnaire, and the reduced rank regression method to determine dietary patterns, using the homeostasis model assessment of insulin resistance as the intermediate or response variable; the association between the dietary pattern identified and incidence of type 2 diabetes was investigated using Cox proportional hazard regression models. The authors identified a dietary pattern characterized by high consumption of low calorie diet, soft drinks, onions, sugar-sweetened beverages, burgers and sausages, crisps and other snacks, and white bread and low consumption of medium-/high-fiber breakfast cereals, jam, French dressing/vinaigrette, and whole meal bread. Higher dietary pattern scores were associated with increased risk of type 2 diabetes. Result demonstrated that a dietary pattern associated with insulin resistance predicts type 2 diabetes risk after adjustment for a range of confounders [8].

Liet al used data from the fifth examination cycle of the Framingham Offspring Study. Among 2875 participants without diabetes, they identified four dietary patterns based on the predominant sources of energy: 'Fruits, Reduced Fat Dairy and Whole Grains', 'Refined Grains and Sweets', 'Beer' and 'Soda'. These findings indicated that consumption of a diet rich in fruits, vegetables, whole grains and reduced fat dairy protects against insulin-resistant phenotypes and

displacing these healthy choices with refined grains, high-fat dairy, sweet baked foods, candy and sugar-sweetened soda may promote insulin-resistant phenotypes [9]. In a cross-sectional study by Esmailzadeh et al, 486 Tehrani female teachers, aged 40–60 y were assessed, and 3 major dietary patterns were identified by factor analysis, the healthy dietary pattern, the Western dietary pattern, and the traditional dietary pattern. These findings indicate that a dietary pattern characterized by high consumption of fruit, vegetables, poultry, and legumes is associated with reduced risk of insulin resistance and the metabolic syndrome in Tehrani female teachers. In contrast, a dietary pattern with high amounts of refined grains, red meat, butter, processed meat, and high-fat dairy products and low amounts of vegetables and low-fat dairy products is associated with a greater risk of the metabolic syndrome [4].

Ishrawe et al, investigated the relationship between dietary nutrients and insulin resistance in 352 Asian Indian adolescents and young adults, dietary nutrient intake was (24-hour dietary recall and monthly consumption data) result showed that for prevention and amelioration of insulin resistance in Asian Indian adolescents and young adults, it is prudent to have normal BMI and low intakes of 6 PUFAs [10].

In a cross-sectional study by Desmond E. M, 802 subjects aged 40–65 years were randomly selected, and principal component analysis was used to identify four dietary patterns explaining 31.7% of the dietary variation in the study cohort. Component 1 was characterized by a healthy balanced diet with a frequent intake of raw and salad vegetables, fruits in summer and winter, fish, pasta and rice and low intake of fried foods, sausages, fried fish, and potatoes. this component was negatively correlated with central obesity, fasting plasma glucose, 120 min non-esterified fatty acid and triacylglycerol, and was positively correlated with HDL-cholesterol. It therefore appears to be protective against metabolic syndrome; this component was also negatively associated with the risk of having undiagnosed diabetes, an association independent of age, sex, smoking and obesity. These findings support the hypothesis that dietary patterns are associated with other lifestyle factors and with glucose intolerance and other features of the metabolic syndrome [11].

In a cross-sectional study by Villegas et al, 1018 men and women sampled from 17 general practice lists in the south of Ireland. Three dietary patterns were identified by cluster analysis; traditional Irish diet including white bread and refined cereals, chips, butter, whole milk and dairy products, deserts and sweets and lowest intake of poultry, fish, pasta and rice, prudent diet including high intake of pasta and rice, brown and unrefined cereals, spreads, poultry, fish, low fat and dairy products, salad dressing, fruit and vegetables and lowest intake of chips, white bread and refined cereals, butter, high fat dairy, meat, meat products and sweet and Alcohol and convenience pattern including high intake of alcohol, meat, meat products, chips and snacks and the lowest intake, of dessert, fruits, vegetable, brown bread and refined cereal, low fat, dairy products and drink; the results showed that prudent diet may be associated with enhanced insulin sensitivity and

lower risk of type 2 diabetes [12]. Another study indicated that adherence to Mediterranean diet, high intakes of non-refined cereals and products, vegetables, legumes, fruits, olive oil, dairy products, fish, pulses, nuts, potatoes, eggs, sweets, poultry, red meat and meat products, was modestly associated with a better insulin sensitivity, lower levels of total cholesterol and lower levels of systolic blood pressure in overweight and obese subjects. This may suggest that compared to general population, the beneficial effect of this diet in cardiovascular system of excess body weight people is limited [13].

In conclusion, results of this systematic review indicate that unhealthy food habits which is rich in trans fatty acids and saturated fatty acids, refined carbohydrate with high glycemic index is related to the insulin resistance, hyperglycemia and risk of diabetes type 2.

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