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Review Article

The Effect of Different Types of Dietary Fatty Acids on Body Fat: A Review

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ABSTRACT

Overweight and obesity are the causes of many diseases. One of the most important and modifiable factors in obesity is dietary changes. Fats are macronutrients that provide more calories than proteins and carbohydrates; therefore, they are blamed for the accumulation of fat mass in the body. Different types of fatty acids have been shown to have different metabolic responses. There is no definite consensus on the effect of different types of fatty acids on body composition, but a review of the literature shows that different fatty acids have important differences in accumulation of adipose tissue. Monounsaturated fatty acid (MUFA) levels of more than 12% of calories in weight loss diets have been significantly associated with further reduction of adipose tissue. Higher blood levels of alpha linolenic acid (n-3) and gamma linoleic acid were inversely associated with weight gain. There is a significant inverse relationship between $\frac{PUFA}{SFA}$ and $\frac{MUFA}{SFA}$ levels and waist circumference and consity index. Methylation of adiponectin gene is altered by overuse of saturated fatty acids (SFAs). SFAs and trans fatty acids (TFAs) have lower oxidation rates than polyunsaturated fatty acids (PUFAs) and MUFAs. This feature makes them more inclined to save. Replacing SFA and TFA with MUFA and PUFA can reduce the accumulation of adipose tissue and maintain more lean body mass. Although it is recommended that about 30% of dietary calories to be obtained from fats, the exact share of each of these fatty acids in diet to achieve the desired results has not been determined, yet.

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Introduction

Obesity is one of the major problems facing human health in the last century, as nearly a third of the world's population is obese or overweight (1). The prevalence of obesity in the population over 18 years of age in Iran in 2014 is estimated to be 21.7% (2). Obesity has been shown to be one of the most important risk factors for many chronic diseases including cardiovascular disease, some cancers, diabetes, hypertension, fatty liver and hyperlipidemia (3). Increased accumulation of adipose tissue is associated with higher secretion of pathogenic products, which leads to worsening of inflammation and the spread or formation of some diseases in the body (4). Obesity is a multifactorial phenomenon, the most important of which are genetics, diet and physical activity (5). However, diet plays a key and modifiable role in the management and control of obesity.

The composition of the diet, including fats, carbohydrates and proteins, are directly related to the distribution of fat and obesity in people. Fats, with 9 kilocalories of energy per gram, are accused with more than other macronutrients to store energy and accumulate fat in the body. However, no dietary standard, including Dietary Reference Intakes (DRI) and Adequate Intake (AI), has been defined for them; and the only recommendation is that the percentage of fat to be 20-35% of the total daily energy intake (6). Fats are classified in several ways. In one classification, they are divided into simple, compound and miscellaneous lipids. In another category that is mostly used in nutritional and dietary studies; they are classified according to the type, length and number of unsaturated bonds. This classification includes (i) unsaturated fatty acids (monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), trans fatty acids (TFA)) and (ii) saturated fatty acids. Different types of fatty acids are associated with different metabolic responses. Saturated fatty acids have been shown to increase high density lipoprotein (HDL) and low density lipoprotein (LDL); while, unsaturated fatty acids reduce HDL and LDL (7).

It is also reported that the $\frac{\omega 6}{\omega 3}$ ratio can be important in the management of blood sugar in diabetic patients (8). However, there is no consensus on the effects of different types of fatty acids on adipose tissue and other components of the body (9-12). Various studies have examined the effect of dietary fats on body composition, but most of these studies have looked at different fats in the same way, and whether different types of fats can have different effects on body composition and obesity remains unclear. In this study, our goal was to explore the role of each fatty acid on body composition by reviewing previous studies.

Unsaturated fatty Acids

MUFA

Fatty acids that have only one unsaturated bond are called MUFAs. Types of dietary MUFAs include caproleic acid, laurolic acid, myristic acid, palmitoleic acid, oleic acid, aladic acid, auxinic acid, gadoleic acid, and erucic acid. However, the most abundant MUFAs are oleic acid (n-9-18:1) and palmitoleic acid (n-7-16:1). Also, the most available and abundant sources of MUFA in the diet are olive oil and nuts (13). A study that compare the different levels of MUFA intake showed that the volume of fat mass significantly reduced in a calorie-restricted diet rich in MUFAs (>12%) when compared with a calorie-restricted diet with low MUFAs (<12%) (14).

But, in studies where MUFA-rich diets have been compared with other diets, the results are different (15, 16). In a clinical trial, medium chain triglycerides (MCTs) were reported to be significantly associated with a reduction in adipose tissue and an increase in energy expenditure and fat oxidation when compared to olive oil (15). In the weight loss program, intervention and placebo groups respectively received 24-18 g/day of MCT oil and olive oil, at the end, body weight, fat volume and trunk fat mass in the MCT group significantly decreased in comparison to olive oil (16).

Other randomized clinical trials (RCTs) have been reported with different results. A RCT compared two groups of obese or overweight men with the equal percentage and different sources of dietary fat. In the group with fat profile of 22% MUFA, 11% SFA, 7% PUFA compared to the other group with fat profile of 13% MUFA, 24% SFA, 3% PUFA; Fat mass and body weight further decreased in the MUFA-rich diet (9). MUFA-rich diets have been shown to inhibit the distribution of central fats and reduce waist to hip ratio (WHR). The possible mechanism can be attributed to the higher oxidation rate of MUFAs than SFAs (10, 17).

PUFA

Fatty acids that have two or more double bonds are called PUFAs. PUFAs with 18 carbon atoms are classified as Short Chain Polyunsaturated fatty acids (SC-PUFA) and PUFAs with 20 carbon atoms are classified as Long Chain Polyunsaturated fatty acids (LC-PUFA). The most important SC-PUFAs are linoleic acid (18:2-n-6) and alpha-linolenic acid (18:3-n-3). Linoleic acid (LA) and alpha linolenic acid (ALA) are essential fatty acids in the diet that are used to make some other fatty acids. The main dietary sources of ALA are vegetable oils, the most abundant of which are safflower, sunflower, corn oil, soybean oil, almond and sesame. The most important LC-PUFAs also include (20:5-n-3) eicosapentaenoic acid (EPA) and (22:6-n-3) docosahexaenoic acid (DHA). Major food sources of EPA and DHA include fish, fish oil, flax seed, chia seed, flax seed oil and walnut. Several health benefits of EPA and DHA have been proven, especially in improving cardiovascular and cerebral function. Imbalances in omega-6 and omega-3 fatty acids affect the condition of many diseases (18, 19). According to the therapeutic lifestyle changes (TLC) recommendations, it is suggested that PUFAs make up a maximum of 10%

of the total daily caloric intake (20).

The results of a cohort study indicated that higher blood levels of ALA (n-3) and gamma linolenic acid (GLA) (n-6) were significantly and inversely associated with weight gain in preschool children (21). In a RCT, visceral fat, body weight and waist circumference were significantly reduced in the ALA recipient group (22). An animal study using chia seeds as the source of fat intake reported that visceral adiposity significantly declined by receiving alpha-linolenic acid (23). However, there is a study to support the lack of significant effect of ALA or LA on body composition (24). Possible suggested mechanisms include increased liver enzymes associated with fatty acid oxidation, stimulation of intestinal beta oxidation, and expression of C57BL/KsJ-db/db-related genes (25). The C57BL/KsJ-db/db gene was associated with the hepatic regulation of lipid and glucose homeostasis (26).

In a previous study, it was reported that dietary intake of 18c:n-3 significantly increased liver enzyme mRNA levels and was associated with fatty acid oxidation, including palmitoyltransferase I and II, mitochondrial trifunctional protein, acyl-CoA oxidase, peroxisomal bifunctional protein, mitochondrial and peroxisomal ketoacyl-CoA thiolases, 2,4-dienoyl-CoA reductase and Δ3, Δ2-en enoyl-CoA isomerase (25). Numerous experiments have been performed to evaluate the effects of PUFA omega-3 on body composition, some of which have reported that the use of PUFA omega-3 can reduce body fat without changing body weight (26-30).

Possible mechanisms for the effect of PUFA omega-3 on weight loss have been suggested: (i) suppression of appetite, (ii) improved blood circulation, (iii) changes in the expression of genes that can lead metabolism to the accumulation of lean tissue, and (iv) increase fat oxidation and energy expenditure. EPA may improve lean body mass (LBM) in patients with cachexia (31). The results of two RCTs showed declined waist circumference following supplementation with fish oil rich in EPA and DHA (30, 32). Supplementation with either EPA, DHA or both has reduced body fat mass (29, 33, 34). However, there are reports that there is no significant change in body fat following supplementation with fish oil (35, 36).

TFA

FFAs are fatty acids that have at least one unsaturated bond in the trans position. Only a limited number of mammals (cattle, sheep, and goats) synthesize TFAs in small amounts. Approximately 30-50% of unsaturated fats are converted from cis to trans during hydrogenation. The presence of TFAs in hydrogenated oils results in longer shelf life, greater stability when deep frying at high temperatures, and solidity at room temperature. The main dietary sources of TFAs include bakery products, frozen food, margarines and popcorn. It is recommended that the diet to be less than 1% of total calories (11, 37). Observational studies have reported a significant relationship between TFA intake and anthropometric indices (12, 38, 39). The results of a cross-sectional study indicate that TFAs had a significant direct relationship with WC and WHR. It has also been shown that the MUFA/SFA and PUFA/SFA ratios were significantly and inversely related to waist circumference and consity index (CI) (39). CI is an anthropometric model that estimates the deposition of abdominal fat. The CI estimates abdominal obesity by using weight, height, and waist circumference (40).

The results of a large cohort study of American men over a 9-year period suggested that replacing TFAs with other unsaturated fatty acids could increase waist circumference (38). However, a human trial of 52 obese healthy postmenopausal women over a 16-week period reported that although the body fat in the TFA group increased body fat compared to the control group, it was not statistically significant (41). In addition to dietary fats, some of the different types of TFAs accumulated in adipose tissue could also be associated with anthropometric indices. A study indicated the inverse associations between 16:1n-7 TFAs of adipose tissue and skinfold thickness and between 18:1 TFAs of adipose tissue and BMI and waist circumference. Although 18:2 TFAs showed the positive associations with measures of adiposity (12).

SFA

Fatty acids, which occupy all the binding sites, fall into the category of SFAs. Saturated fatty acids are associated with the onset and exacerbation of many diseases, including cardiovascular diseases. Most dietary recommendations suggest that the maximum dietary intake of SFAs should not exceed 10% (42). Cross-sectional studies have reported a significant direct relationship between higher saturated fatty acid intake with BMI, WHR, and increased adipose tissue (43, 44). Changes in the ratio of dietary fatty acids without changes in the amount and percentage of fats are associated with different metabolic responses (45-47). In very low fat diets (Fat: 10%, Proteins: 20%, Carbohydrates: 70%, SFA: 3%) and diets with a very high percentage of SFA (Fat: 60%, Proteins: 35%, Carbohydrates: 4%, SFA: 20%) compared to a diet with reasonable percentages of macronutrients (Fat: 30%, Proteins: 20%, Carbohydrates: 50%,), loss of lean mass was significantly higher (45).

Besides, it was shown that a diet high in fat and saturated fat (Fat: 55%, Carbohydrates: 27%, SFA: 25%) for 28 days has been associated with increased insulin resistance in obese/overweight individuals without significant change in gaining weight (48). In an RCT where Cream was used as the source of SFA supply, it was significantly associated with a lower oxidation rate than olive oil (49). The lower oxidation rate of SFAs than PUFAs and MUFAs is probably due to the greater accumulation of adipose tissue. Another RCT has also reported that methylation of the adiponectin gene is altered by increased SFA intake. Adiponectin plays an important role in the homeostasis of total energy expenditure by modulating glucose and lipid metabolism. DNA hypermethylation of adiponectin gene suppresses the adiponectin expression (47). Using PUFAs insTFAd of SFAs in the diet without any other dietary changes reduces abdominal fat and ectopic fat without changing body weight and also improves insulin resistance (6, 46).

Conclusion

Different types of fatty acids were shown to have different and sometimes conflicting metabolic responses. However, less attention has been paid to the effect of different types of fatty acids on anthropometric and body fat indices. Different types of fatty acids differ in oxidation rate, energy expenditure, and effect on the expression of genes related to body composition. SFAs and TFAs have lower oxidation rates than unsaturated fatty acids, which could possibly be associated with greater accumulation of adipose tissue. Diets with high percentages of fat, in addition to providing higher energy, can be associated with higher intakes of SFA and TFA. Although total calories may be restricted in weight loss programs, studies in this study may cast doubt on the effective reduction of adipose tissue in diets with higher SFA and TFA compared to other weight loss diets. Also, nowadays, following the development and expansion of industries, and changing dietary habits, the use of TFA and SFA food sources has increased, which are associated with greater accumulation of fat mass. Some studies have reported that replacing SFAs with PUFA or MUFA in the diet can further reduce fat mass and maintain lean body mass. Although for cardiovascular disease, the percentage of each fatty acid is specifically defined in the guidelines, the exact proportion and percentage of use of different types of fatty acids in weight loss programs to achieve the best results, including further reduction of fat mass and the maintenance of lean tissue has not yet been determined.

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Conflict of Interest

None declared.

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