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Review

Health benefits of nut consumption with special reference to body weight control

Vellingiri Vadivel Ph.D. [a,*], Catherine N. Kunyanga Ph.D. [b], Hans K. Biesalski M.D., Ph.D. [a]

[a] Institute for Biological Chemistry and Nutrition, University of Hohenheim, Stuttgart, Germany
[b] Department of Food Science, Nutrition and Technology, University of Nairobi, Nairobi, Kenya

ABSTRACT

Nuts are an integral part of the Mediterranean food patterns, and their incorporation into the regular diets of human beings is believed to provide many health benefits. The recent recognition of nuts as "heart-healthy" foods by the U.S. Food and Drug Administration has given a major boost to the positive image of nuts. Nut consumption has been associated with several health benefits, such as antioxidant, hypocholesterolemic, cardioprotective, anticancer, anti-inflammatory, and antidiabetic benefits, among other functional properties. However, although nuts possess these many health benefits, their consumption has been hampered by a lack of adequate information regarding those benefits. In addition, because nuts are energy-dense foods with high-fat content, there is a misconception among consumers that increased consumption may lead to unwanted gain in body weight with the risk of developing overweight/obesity. Nonetheless, available epidemiologic studies and short-term controlled feeding trials have supported the theory that the inclusion of nuts in the typical diet does not induce weight gain, despite an expected increase in total caloric intake. To address the misperception about nuts and body weight gain, the present review focuses mainly on the relation between nut consumption and body weight gain, in the context of the many health benefits of nuts.

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Introduction

Nuts are recommended as an important constituent of a healthy diet in human populations throughout the world. Various types of nuts such as almonds, Brazil nuts, hazelnuts, macadamia nuts, peanuts, pecans, pine nuts, pistachios, kola nuts, walnuts, and cashews are commonly consumed by human beings, although individual intake varies remarkably. In general, nuts are energy dense and provide 23.4 to 26.8 kJ/g of food with a high-fat content (45–75% of weight), but mostly unsaturated fat [1]. Nuts are also rich sources of protein, unsaturated fatty acids, fiber, vitamins (vitamins E and B6, folic acid, and niacin), minerals (magnesium, potassium, and copper), phytosterols (stigmasterol, campesterol, and sitosterol), and polyphenols (catechins, resveratrol, etc.) [2]. Nuts are an integral part the Mediterranean food pattern and constitute a substantial intake of dietary fat (up to 35–40% of total energy intake) [3]. Adherence to the Mediterranean diet has resulted in protection against mortality from causes such as the development of coronary heart disease (CHD), stroke, hypertension, and cancer [4–11].

Results from several epidemiologic studies have suggested that there may be a connection between frequent nut consumption and decreased incidences of several chronic diseases [12]. Recent emerging scientific proofs have demonstrated that the bioactive constituents of whole nuts have cardioprotective, antiobesity, anticancer, and antioxidant effects mediated by several different mechanisms [13]. Epidemiologic studies and clinical interventions have clearly shown that nut consumption is associated with stable or low body weight gain [14–19].

Nevertheless, nuts have been perceived by the general public as fattening because of their high-fat content. In Europe, rates of obesity are higher in the Mediterranean countries compared with Nordic countries [20]. Therefore, there is a common misconception that nuts exacerbate the obesity trend in the Mediterranean region [21]. Health professionals have also acquired the impression that nut consumption by hypercholesterolemic patients leads to more weight gain [22]. However, the hypothesis that

a high-fat diet always increases body weight is controversial [23]. There is more misunderstanding of the notion that fat causes weight gain compared with other sources of calories [23–25]. This notion has come to the forefront of debate after the publication of the results from the Women's Health Initiative Dietary Modification Trial, which showed no substantial weight loss after adhering to a low-fat diet [26]. McManus et al. [27] also reported that obese subjects who followed a moderate-fat diet exhibited greater and more sustained weight loss than similar subjects who followed a low-fat diet.

Recently, Pawlak et al. [28] conducted personal interviews about nut consumption in the general public in North Carolina and one-third believed that eating nuts might be helpful in lowering the cholesterol level, whereas more than one-third believed eating nuts would cause weight gain. Thus, there are contradictory or conflicting opinions about the relation between nut consumption and body weight gain; hence, the real effects of nut consumption should be thoroughly discussed. Therefore, the present review aims to elucidate the link between nut consumption and body weight gain, in addition to the other health benefits of the consumption of nuts such as their antioxidant, hypocholesterolemic, and cardioprotective effects.

Antioxidant effects

Nuts are an important source of tocopherols and phenolic antioxidants and the protective effects of these dietary constituents on low-density lipoprotein (LDL) oxidation have been well documented in human and animal studies [29]. Recently, walnuts have been shown to contain substantial amounts of melatonin, which has been found to contribute to a significant antioxidant effect in experimental rats [30]. A cashew diet resulted in an increased antioxidant capacity in human subjects with the metabolic syndrome [31]. Further, Brazil nut consumption has been reported to increase the selenium status and glutathione peroxidase activity in obese women [32].

Oxidative markers after the feeding of nuts rich in monounsaturated fatty acids (MUFAs) have been examined in several clinical trials. Single feeding trials with diets rich in hazelnuts [33], pistachios [34], and macadamia nuts [35] have resulted in an improved oxidation status. Diet enriched with peanut oil/peanut and peanut butter have shown improved LDL oxidization compared with an average American diet rich in other fats [36]. In agreement, studies of walnuts rich in polyunsaturated fatty acids (PUFAs) have shown a resistance of LDL to in vitro oxidative stress [37–39]. Thus, the tocopherols and other antioxidants present in walnuts likely prevent the potential adverse effects of increasing the LDL content of PUFAs. In contrast, Berry et al. [40] found that the oxidation of plasma and LDL lipids in healthy volunteers was lower after an almond diet compared with a low-fat diet.

Hypocholesterolemic effects

Nuts have been reported to have a low value on the glycemic index [41]. Nuts have been shown to decrease total cholesterol (TC) and LDL cholesterol (LDL-C) concentrations in human subjects [42]. The consumption of nuts as part of a healthy diet has been shown to have a positive influence on the fatty acid profile of persons with type 2 diabetes mellitus (T2DM) [43]. The health benefits of walnuts, including lowering cholesterol levels, increasing the ratio of high-density lipoprotein cholesterol (HDL-C) to TC, decreasing inflammation, and improving arterial function, have been noted in patients with T2DM and hyperlipidemia

[37,44–46]. Zhao et al. [45] concluded that a diet high in walnuts (containing α-linolenic acid) elicited cardioprotective and vascular anti-inflammatory effects. Regarding the latter, it has been reported that walnuts are rich in antioxidants compared with other dietary plants [47], and several health effects, including decreased inflammation, have been ascribed to walnut flavonoids [48].

Mukuddem-Petersen et al. [49] studied the effect of diets high in walnuts and cashews on the markers of the metabolic syndrome in human subjects. The results indicated that the subjects displayed no improvement in the markers for the metabolic syndrome after a walnut or cashew diet compared with a control diet while maintaining a constant body weight. The walnut and cashew intervention diets had no significant effect on the TC, LDL-C, and HDL-C levels in the human groups. Most study subjects were obese and sedentary; therefore, with such a high degree of obesity, even a nut-rich diet may not suffice in inducing the beneficial effects without weight loss. Primarily, the maintenance of body weight may have masked the positive metabolic effects of the nut diets.

Cardioprotective effects

Chisholm et al. [50] reported that nut consumption has a TC-lowering effect and decreases the risk of lipoprotein-mediated cardiovascular diseases (CVDs). Previous studies have consistently showed an association between nut consumption and a lower risk of CVD [13,14,17,51] and an improvement in serum lipid and lipoprotein profiles [15,17,52]. For this reason, the American Heart Association has recommended nut consumption since 2000 [53].

Epidemiologic findings have indicated that frequent nut consumption offers protection against fatal and non-fatal CHD [54]. Emerging research trends have suggested possible health benefits associated with modest increases in dietary α-linolenic acid (from walnuts), including lower blood pressure [55–57]. In addition, a study conducted in healthy and hypertensive individuals has shown the beneficial effects of MUFA (from cashew nuts) on blood pressure [58]. A substantial decrease in the risk of CHD (50%) in persons with a low or high body mass index (BMI) consuming nuts more than five times per week compared with their counterparts consuming nuts less often than one time per week has been reported by the Adventist Health Study [22]. A similar trend has been demonstrated in the Nurses' Health Study [17]. Because obese individuals are at greater risk for CHD, it correct to suggest that nut consumption may actually decrease this risk.

Effect on body weight gain

In general, there is continued concern that the increased consumption of energy-dense nuts may lead to excessive weight gain. Findings from epidemiologic studies, however, have disputed the idea that frequent nut consumption leads to weight gain [13,14,17]. Interestingly, the per-capita nut consumption in Mediterranean populations is about double than that of the United States, which has much higher obesity rates [54]. As a result, the belief that nuts are unhealthy because of their high fat content is not widely accepted by the general public and health professionals.

Similarly, certain ecologic data have not related long-term nut consumption with obesity. A cross-sectional study in 800 schoolgirls in Spain found no relation between the frequency of nut consumption and body weight [59]. Albert et al. [13] also

observed no apparent association between BMI and nut consumption in the Physician's Health Study.

The association between nut consumption and a decrease in body weight gain has been reported from many human trials [49, 60–63]. In many large cohort studies, an inverse relation has also been noticed between nut consumption and BMI. Therefore, one can conclude from the outcome of previous experiments that frequent nut consumption is not necessarily associated with body weight gain, but it can lower the risk of obesity in healthy human subjects and those with the metabolic syndrome. The long-term consumption of nuts has been reported to be associated with a lower risk of body weight gain and obesity [1]. Wien et al. [64] reported that a low-energy nut diet resulted in a sustained decrease in weight and improved the preponderance of abnormalities associated with the metabolic syndrome.

Epidemiologic studies on body weight gain

Previous epidemiologic studies have provided strong evidence that the addition of nuts to usual diets does not adversely affect body weight [65]. An inverse relation between the frequency of nut intake and BMI has been observed in all large cohort studies. When the association between nut consumption and T2DM was assessed in the Nurses' Health Study, it was found that the women who consumed more nuts tended to lose body weight [61]. When the association between nut consumption and CHD was examined in the Adventist Health Study cohort, a significant inverse cross-sectional association between nut consumption and BMI was observed [14]. According to the Physician's Health Study, men who consumed nuts two or more times per week had lower BMIs than those who consumed nuts only once a week or less [13].

The Seguimiento Universidad de Navarra study is an epidemiologic study that examined the direct effect of nut consumption on body weight in a Mediterranean population in a prospective fashion [60]. This study, which involved 8865 adult men and women, found that those who ate nuts frequently (more than two times per week) had a 40% lower risk of weight gain; even after adjusting for the baseline BMI, the obesity rate was 0.69. Specifically, the frequent nut consumers gained 350 g less weight than those who never ate nuts during a follow-up period of 28 mo (Fig. 1). Frequent nut consumption (at least two times per week with 50 g/serving) was inversely associated with the risk of becoming overweight or obese. When the results were adjusted for age and sex, the participants who consumed nuts at least two times per week decreased their risk of becoming overweight/obese by 43% compared with those who never consumed nuts. Similarly, 30% of participants who consumed nuts at least two times per week were less likely to gain weight (≥5 kg) compared with those who rarely ate nuts [60].

To determine the relation between nut consumption and long-term weight change, Bes-Rastrollo et al. [1] assessed the effect of a dietary intake of nuts and subsequent weight changes in 51 188 women 20 to 45 y old in the Nurses' Health Study II from 1991 to 1999. The women were healthy and middle-aged and had no CVD, diabetes, or cancer. The results indicated that a higher nut consumption was not associated with a greater body weight gain during the 8-y follow-up study in these healthy middle-aged women. Instead, greater nut consumption (more than two times per week) was associated with a slightly lower risk of weight gain and obesity (Fig. 2). When the total nut consumption was subdivided into peanuts and tree nuts, the results were similar. The results were also similar for normal-
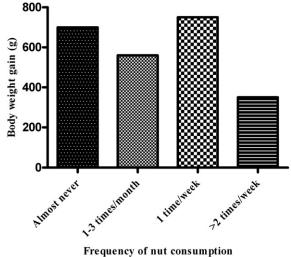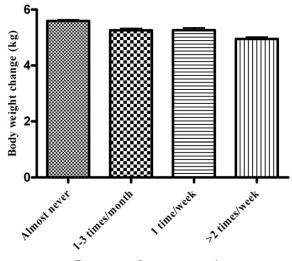

Fig. 1. Estimated weight gain in nut eaters and non-nut eaters according to the Seguimiento Universidad de Navarra study [60].

weight, overweight, and obese participants. The outcome of this study suggests that the incorporation of nuts into the diet does not lead to a greater weight gain and may even help in weight control. Similarly, O'Byrne et al. [18] reported a significant weight loss of 3 kg over 6 mo in the human group fed with nuts. This study also demonstrated that the isocaloric replacement of nuts for other foods in the diet did not lead to weight gain.

A food intake survey conducted by the U.S. Department of Agriculture from 1994 to 1996 was used to compare the BMI and total energy intake of nut eaters with those of non-nut eaters [66]. The data showed that young (6–20 y old) and adult (>21 y old) nut eaters had lower BMIs compared with the respective non-nut eaters (Fig. 3), although the energy intake was high in nut consumers. Likewise, in nut eaters, the amount of nuts in their diet did not relate to the BMI. These results indicate that there is an inverse relation between the intake of nuts and BMI in the U.S. population.

Fig. 2. Body weight changes over 8 y according to the frequency of nut consumption in 51 188 women [1].
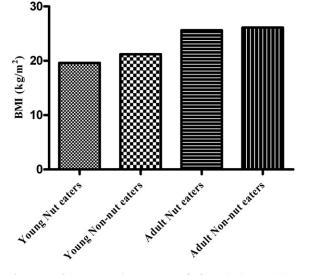
Fig. 3. BMI of nut eaters and non-nut eaters [66]. BMI, body mass index.

Similarly, the Adventist Health Study reported a statistically significant negative association between the consumption of nuts and the BMI in a cohort of 31 200 Californian subjects, showing that those who ate nuts more frequently were leaner than the infrequent nut eaters [14]. Hu et al. [17] also observed a negative association between nut consumption and BMI in 86 000 women in the Nurses' Health Study. The BMIs by quartile of nut consumption (from never to two times per week) ranged from 24.7 to 24.9 in the cohort of 21 500 men [14,17].

Further, people who eat nuts may tend to engage in higher levels of physical activity than non-nut eaters. Hu et al. [17] reported that nut consumption was associated with a greater frequency of vigorous exercise in the Nurses' Health Study participants. The Physician's Health Study [13] also noted that men who ate nuts more frequently were physically more active. However, in a study in which the habitual diets of free-living subjects were supplemented with almonds for 6 mo, no changes in vigorous exercise were noted [67].

Almonds and body weight gain

Almonds are the most consumed tree nut, with a per-capita consumption of 1 lb./y in the USA [68]. Almonds have cardioprotective effects because they are an excellent source of unsaturated fats, α-tocopherol, dietary fiber, copper, magnesium, arginine, plant sterols, and polyphenols [69,70]. Regarding glycemic control, Jenkins et al. [71] found that almond consumption lowered postprandial glucose excursion in healthy individuals. However, Lovejoy et al. [72] observed that almonds incorporated into a low- or a high-fat diet did not affect glycemia and lipid profiles of American patients with T2DM.

Most almond studies in the literature have illustrated the hypolipidemic effect of almonds in healthy subjects or hypercholesterolemic patients. Almonds are a high-fat, energy-dense food. However, observational and clinical studies have shown that almond consumption is not associated with a higher BMI or weight gain [73]. Almond supplementation for 6 mo in human subjects exhibited only minimal effects on body weight [67]. Eighty-one subjects each were provided with 42 to 70 g/d of raw or dry-roasted almonds, and after 6 mo of almond supplementation, men gained 0.65 kg, whereas women did not show

significant gains in weight. Only lean subjects gained weight during the almond supplementation phase and women in the highest baseline BMI tertile actively lost weight. Thus, the daily incorporation of a modest quantity of almonds for 6 mo did not lead to significant changes in body weight. Other small trials have found that when almond nuts are added to the diet, there is no associated weight gain, although total energy intake increased substantially [73,74]. Similarly, almond intervention trials in controlled and free-living conditions have shown no adverse effect on energy balance or body weight [75].

Three well-designed studies with almond-supplemented diets (54–100 g/d) showed significant decreases in TC and LDL-C in hypocholesterolemic [76,77] and normocholesterolemic [78] human subjects. In agreement, the consumption of almond-supplemented diets (60 g/d) decreased TC, LDL-C, and the ratio of LDL-C to HDL-C by 6%, 11.6%, and 9.7%, respectively, in 20 Chinese patients with T2DM [79]. In contrast, body fat and BMI were not increased in patients administered for 4 wk with an almond diet compared with control subjects (Fig. 4). Lovejoy et al. [72] reported that the inclusion of 57 to 113 g of almonds per day had no significant effect on the blood lipid profile of subjects with T2DM compared with a high-fat control group. The same outcome was achieved when the same amount of almonds was incorporated as a part of a low-fat diet.

Jenkins et al. [77] compared two different doses of almonds with a low-fat diet in hyperlipidemic subjects and observed a 14% decrease in plasma oxidized LDL levels after the higher dose (73 g/d). However, Hyson et al. [75] found no improvement in the susceptibility of LDL to an oxidative stress above the baseline level after feeding almonds or almond oil to healthy individuals, although the saturated fatty acid (SFA) intake was lower in the almond diets.

Peanuts and body weight gain

Alper and Mattes [16] investigated the effect of peanut supplementation (89 g) on weight gain in 15 adults with normal weight (provided with 500 kcal/d) under free-feeding, addition, and substitution phases. During the substitution period, no weight gain was observed, but in the free-feeding phase, subjects gained 1 kg during the 8-wk intervention, considerably less than the predicted 3.6 kg from the additional calories provided. Similarly, during the additional period, subjects gained only 0.6 kg, although 1.4 kg had been predicted. Hence, peanut consumption does not lead to a high body weight gain in human subjects.

Coelho et al. [80] evaluated the effects of peanut oil intake on appetite, energy expenditure (EE), body composition, and lipid
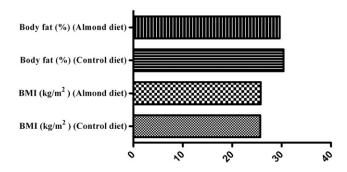

Fig. 4. BMI and body fat levels of patients with type 2 diabetes mellitus administered with an almond nut diet for 4 wk [79]. BMI, body mass index.

profile in lean and overweight adults. The results of this 8-wk trial with 48 adults indicated that energy intake was increased significantly in the overweight but not in the lean participants. A statistically significant body weight gain (median 2.35 kg) was also observed in the overweight subjects, although this corresponded only to 43% of the theoretical weight gain. In overweight subjects, HDL-C increased significantly and LDL-C decreased in the fourth week. Resting EE was 5% greater in the overweight group, but no significant difference was observed in the lean subjects. There were no marked differences of appetite realized over time in the overweight or lean participants.

Walnuts and body weight gain

In a randomized, crossover trial, Sabate et al. [81] found a minimal weight gain in the subjects who ate 28 to 56 g of walnuts daily for 6 mo. Jenkins et al [82] reported that the weight gain associated with walnut consumption was considerably lower than the predicted level, whereas Almario et al. [19] observed no significant change in body weight and the percentage of body fat from walnut consumption. Sabate et al. [52] evaluated a blood cholesterol-lowering diet that provided 20% of energy from walnuts and 31% of energy from fat, of which 6% came from SFAs and 16% from PUFAs. The TC and LDL-C levels were decreased by 12 and 18%, respectively, in the normocholesterolemic subjects administered with walnut-containing diets.

Four of seven well-designed studies on walnuts (40–84 g/d) found a significant decrease in TC and LDL-C compared with the Step I [51], Mediterranean [37,38], and Japanese [39] diets. Two of the studies showed no significant change in the lipid profiles of hyperlipidemic subjects on a walnut intervention diet (64–78 g/d) compared with the low-fat and Step I diets [83,84], suggesting that the beneficial effects of nuts disappeared with high-fat intakes.

In a randomized, crossover, feeding trial, 25 normal to mildly hyperlipidemic adults consumed three isoenergetic diets for 4 wk each—a control diet (no nuts or fish), a walnut diet (42.5 g/ 10.1 mJ), or a fish diet (113 g of salmon, twice per week)—that were analyzed for serum lipids [85]. Serum TC and LDL-C concentrations in adults who followed the walnut diet were lower than in those who followed the control and fish diets. The ratios of TC to HDL-C and LDL-C to HDL-C were significantly lower in those who followed the walnut diet compared with those who followed the control and fish diets. Hence, the inclusion of walnuts in a healthy diet can decrease serum cholesterol concentrations [85].

Fifty-eight subjects were randomized into three treatment arms of different dietary advice: a conventional low-fat control diet, a low- but modified-fat diet higher in eicosapentaenoic and docosahexaenoic acids and PUFAs, and a low-fat plus a diet of walnuts 30 g/d high in α-linolenic acid [44]. The results indicated that body fat did not change during the walnut (30 g/d) intervention period of 6 mo compared with the baseline level (Fig. 5). Moreover, the plasma HDL-C/TC ratio and HDL-C were increased and plasma LDL-C was decreased by 10% in the walnut group compared with the other groups. The effect on lipids was attributed to changes in the PUFA/SFA ratio, which were largely caused by the walnut consumption.

Further, Banel and Hu [86] reviewed 13 studies involving 365 participants who were administered with walnut-containing diets for 4 to 24 wk. The results showed that the walnut-containing diets produced significantly greater decreases in TC and LDL-C concentrations compared with the control diets. At
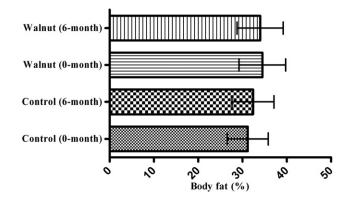

Fig. 5. Body fat levels at baseline and after a 6-mo intervention with walnuts (30 g/ d) in subjects with type 2 diabetes mellitus.

the same time, HDL-C and triacylglycerols were not significantly affected by the walnut diets compared with the control diets. Thus, they concluded that walnut consumption had no adverse effect on body weight. However, long-term trials are necessary to address the effect of walnut consumption on body weight gain.

Pistachios and body weight gain

Pistacia vera L. is a member of the Anacardiaceae family, native to the arid zones of Central and West Asia and distributed throughout the Mediterranean basin. The genus *Pistacia* contains only 11 species, among which pistachio, cultivated for its edible nuts, is by far the most important economically. In Turkey, the pistachio is grown mainly in Gaziantep [87]. The effect of pistachio consumption on the blood lipids of rats fed with a high-fat diet for 8 wk was analyzed by Alturfan et al. [88]. Pistachio consumption significantly decreased triacylglycerols in the hyperlipidemic group of rats. Hence, pistachio supplementation may improve blood lipids in experimental hyperlipidemia, which may have beneficial applications in the prevention or treatment of obesity. Kay et al. [89] evaluated the effect of two doses of pistachios on the oxidative status of 28 hypercholesterolemic subjects. The results showed that pistachios contributed to the decrease in serum oxidized LDL concentration through a cholesterol-lowering effect. Moreover, Honselman et al. [90] demonstrated that in-shell pistachio nuts decrease the caloric intake compared with shelled nuts.

Mixed nuts and body weight gain

In a review published by Griel and Kris-Etherton [91], 10 of 17 controlled feeding studies with nuts demonstrated a decrease in LDL-C. The predicted average decrease in LDL-C for these 17 studies was −0.23 mmol/L with an observed average decrease of −0.29 mmol/L among the tree nut-rich diets. Since this study, more than 25 clinical studies have been conducted to evaluate the effects of nut consumption on serum lipids and lipoproteins. Although the degree of dietary control has been variable, ranging from being tightly controlled to simply providing dietary advice, the results have been consistent in showing a cholesterol-lowering effect of regular nut consumption [90,91]. In agreement, Mukuddem-Petersen et al. [42] showed that the consumption of 50 to 100 g of nuts at least five times per week as a part of a heart-healthy diet with a total fat content of 35% in a randomized controlled intervention trial significantly decreased TC and LDL-C. This decrease was not solely from the

changes in fatty acid composition that resulted from the inclusion of the nuts in the diets, but also a result of the other components found in nuts.

Nut intake has been found to decrease the quintiles of BMI and waist circumference. Alcohol ingestion has been inversely related to BMI, whereas alcohol and meat intake has been directly associated with waist circumference. In fully adjusted multivariable models, independent dietary associations of the BMI and the intake of nuts have been inversely related and that of meat and meat products have been directly related. In regard to waist circumference, independent dietary associations with the intake of nuts and vegetables have been inversely related, whereas the intake of meat and meat products has been directly associated. The dietary determinants of adiposity in an elderly Mediterranean population with customarily high nut consumption were examined by Casas-Agustench et al. [92]. The BMI and waist circumference decreased by 0.78 kg/m^2 and 2.1 cm, respectively, for each 30-g serving of mixed nuts (15 g of walnuts, 7.5 g of almonds, and 7.5 g of hazelnuts) in men and women.

Some dietary intervention studies conducted on different types of nuts have provided substantial evidence that the short-term consumption of moderate to larger amounts of nuts does not increase body weight [15,93]. Further, none of the well-controlled metabolic-type feeding trials have shown significant changes in body weight when the consumption of the nut diet and the non-nut control diet are compared [15,39,52,94, 95]. The controlled crossover feeding studies [51,95] conducted at Loma Linda University with walnuts, pecans, and almonds showed that the subjects consuming the nuts tended to be hungrier and required more energy intake to maintain their body weights than the nut-free control diets. Further, the inclusion of walnuts or cashew nuts into the diets of 64 human subjects with the metabolic syndrome for an intervention period of 8 wk did not show any body weight gain (Fig. 6) [49].

McManus et al. [27] reported that obese subjects on a prescription of a moderate-fat diet containing several nuts, peanut butter, and olive oil exhibited a more sustained weight loss. In a parallel feeding Prevención con Dieta Mediterránea (PREDIMED) s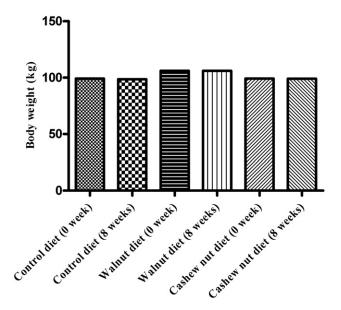tudy [96], a Mediterranean diet enriched with 30 g of raw nuts (15 g of walnuts, 7.5 g of almonds, and 7.5 g of hazelnuts) given daily for 3 mo to older subjects at higher CVD risk resulted in a lower oxidized LDL level (−7.3 U/L) compared with a control diet of a similar SFA content (−2.9 U/L).

Mechanisms of body weight control

There are various mechanistic hypotheses that could explain the biological plausibility of the association between nut consumption and the lack of weight gain, despite a high total energy intake in frequent nut eaters. 1) Although nuts are high in fat, the fat is mostly unsaturated (Table 1). The combination of unsaturated fat and a high protein content found in nuts can lead to an increase in resting EE and diet-induced thermogenesis [98–102]. 2) Nuts may increase satiety, because they are energy dense and a good source of fiber and vegetable proteins, which are known to increase satiety ratings [103–106]. 3) Bes-Rastrollo et al [60] postulated that a high supply of fiber may be a mechanistic explanation of why nuts aid in the prevention of weight gain. 4) Wien et al. [64] showed that the substitution of nuts for carbohydrates improves insulin sensitivity, leading to weight loss. 5) The structure of lipid-storing granules in nuts and their various fiber components and incomplete mastication may cause a low level of fat absorption that could result in the loss of available energy [66,107,108]. 6) In addition, other mechanistic explanations may be related to the several bioactive compounds present in nuts [109].

Among the suggested reasons as to why nut consumption is not associated with an increased BMI in free-living individuals include reverse causation, a higher EE through physical activity or an increased resting metabolic rate, an increased satiety and a corresponding decreased intake of other foods, and an incomplete absorption of energy from the nuts. Reverse causation may explain to some extent the reported inverse relation between nut consumption and BMI found in consumer surveys and baseline data of cohort studies. Obese people may tend to avoid nuts because of their high fat and energy content, whereas lean individuals may have fewer reservations about nut consumption. Dietary compensation seems to be a major reason for the lack of the predicted weight gain in long-term nut-supplemented diets. In a 6-mo almond-supplemented study, 54% to 78% of the extra energy from almonds was displaced by decreases in other foods [67]. Similar observations have been reported in a peanut study of shorter duration [82].

Fecal fat loss because of an incomplete mastication of nuts has resulted in a loss of available energy. Previous work has shown that whole nuts are inefficiently absorbed [107]. Subjects fed

Fig. 6. Body weight level of human subjects with the metabolic syndrome during intervention studies with cashew nut and walnut diets for 8 wk [49].

Table 1
Fat composition of nuts

Nuts	Total fat (% weight)	SFAs (% total fat)	MUFAs (% total fat)	PUFAs (% total fat)	UFAs/ SFAs
Almond	52	10	68	22	9.0
Brazil nut	66	26	36	38	2.8
Cashew	46	20	62	18	3.9
Hazelnut	63	8	82	10	11.9
Macadamia nut	74	16	82	2	5.4
Peanut	49	15	51	34	5.7
Pecan	68	8	66	26	10.9
Pine nut	61	15	40	45	5.4
Pistachio	48	13	72	15	6.6
Walnut	62	10	24	66	9.0

MUFAs, monounsaturated fatty acids; PUFAs, polyunsaturated fatty acids; SFAs, saturated fatty acids; UFAs, unsaturated fatty acids
From the USDARS (2001).[97]

with whole peanuts excreted 17% of the dietary fat in the stool; only 4% to 7% of the dietary fat was excreted when the rats were fed peanut butter [107]. In a well-controlled feeding trial with pecans [95], there was an increased excretion of fats in the stools of subjects (25 g/d) compared with the control diet (6 g/d). This represented 8% and 3% of the dietary fat of the pecan and control diets, respectively [110]. An increased stool fat (4%) also has been noted with a high almond diet [111]. Nevertheless, the losses of fat in the stools of nut eaters combined with the observed food displacement would largely explain the lack of weight gain.

Nuts are rich in unsaturated fatty acids and generally contain substantial amounts of MUFAs (Table 1) [66]; walnuts are especially rich in linoleic acid, α-linolenic acid, and PUFAs. Healthy unsaturated fats in nuts contribute to the beneficial effects of frequent nut intakes observed in epidemiologic studies. In rats, a diet high in unsaturated fats has been shown to lead to a considerable low weight gain and more oxygen consumption than a high-fat diet [112,113]. In humans, a high PUFA/SFA ratio in the diet has been shown to increase resting EE and diet-induced thermogenesis [98,114]. Alper and Mattes [16] reported 11% greater resting EE in 15 subjects after peanut consumption for 19 wk. Peanuts have been shown to produce a strong suppression of hunger and to affect subsequent food intake in a preload study [115].

Nuts are complex food matrices and sources of various bioactive compounds such as tocopherols, phytosterols, and phenolic compounds [15]. Recently, our laboratory has reported that the cashew nut kernels possess appreciable levels of β-carotene (9.57 µg/100 g dry matter (DM)), lutein (30.29 µg/100 g DM), zeaxanthin (0.56 µg/100 g DM), α-tocopherol (0.29 mg/100 g DM), γ-tocopherol (1.10 mg/100 g DM), thiamine (1.08 mg/100 g DM), stearic acid (4.96 g/100 g DM), oleic acid (21.87 g/100 g DM), and linoleic acid (5.55 g/100 g DM) [116], which produce many potential health benefits in consumers.

Further, in recent years, various phenolic compounds have been identified in edible nuts, including almonds [117–119], Brazil nuts [120], chestnuts [121], hazelnuts [122], peanuts [123, 124], pecans [125], pistachios [126], and walnuts [127]. Moreover, Sang et al. [128] identified the presence of nine different phenolic compounds, including catechins, in the almond nut skins with very strong 2,2-diphenyl-1-picryl-hydrazyl (DPPH) free radical scavenging activity. In our previous work, we also demonstrated the presence of (+)-catechin and (−)-epicatechin with concentrations of 5.70 and 4.46 g/kg DM, respectively, in cashew nut testa [129].

Remarkably, most phenolic antioxidants are located in the testa and more than 50% of them are lost owing to the removal of the testa during processing [29]. This fact, which was rarely taken into consideration in previous feeding trials with nuts, should not be overlooked in future studies. Walnuts are an exception, because they are almost always consumed with skins.

Conclusion

Nuts have been showed to possess many health benefits including antioxidant, cardioprotective, antidiabetic, hypocholesterolemic, and anti-inflammatory properties; hence, frequent nut consumption is recommendable to improve the health status of human beings. However, misconceptions are common regarding the high-fat content of nuts and body weight gain, and tend to affect nut intake. In reality, several epidemiologic research studies and short-term feeding trials have shown that moderate nut consumption does not increase body weight. Although nuts have a high-fat content, most consist of

unsaturated fats, which are poorly absorbed and actually induce energy expenditure by thermogenesis. Further, because of the high energy density and protein and fiber content, nuts increase satiety. In addition, the presence of certain bioactive compounds including polyphenols in nuts is assumed to have beneficial roles in body weight control, although this needs scientific validation. Hence, the incorporation of edible nuts, around 30 to 50 g/d, in the typical diet would be advisable to ensure various health benefits without the risk of body weight gain. Nevertheless, except for almonds, peanuts, pistachios, and walnuts, the impact of other nuts on body weight has not been well investigated, and long-term feeding trials in human beings are necessary to provide greater clarity the complexity of the association between nut consumption and body weight gain.

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