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# ORIGINAL COMMUNICATION

# Nut consumption, body weight and insulin resistance

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The beneficial effects of nuts on cardiovascular health are well known. However, since nuts provide a high caloric and fat content, some concern exists regarding a potential detrimental effect on body weight and insulin resistance. The current data available did not support such a negative effect of nut consumption on the short term or when nuts are included on diets that meet energy needs. Furthermore, there is some intriguing evidence that nuts can help to regulate body weight and protect against type II diabetes. This, however, still has to be proved and more research is needed to address the specific effects of nuts on satiety, energy balance, body weight and insulin resistance.
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## Introduction

Nuts have traditionally been considered foods with a high nutritional value. Every variety has particular characteristics but, in general terms, nuts provide between 23.4 and 26.8 kJ/g, and are low in saturated fat (<7%) but very rich in unsaturated fats (40–60%), mainly polyunsaturated in walnuts and pine nuts, and monounsaturated in almonds, hazelnuts, pistachios and peanuts. Nuts are one of the most important sources of dietary fiber, and good sources of plant proteins, antioxidants, vitamins, minerals and numerous bioactive substances, such as flavonoids or phytosterols, which may have health benefits.

Large prospective observational studies have shown that daily consumption of small amounts of nuts can protect against coronary heart disease (Albert *et al*, 2002) and all-cause mortality (Fraser & Shavlik, 1997). Likewise, intervention trials have shown that nut supplementation can improve serum lipid profile (*see for* review Feldman, 2002). However, since nuts are energy dense and fatty, their consumption has been limited by the potential negative impact on body weight and insulin resistance. Data on this issue are scarce as yet and in most cases are based on indirect evidence. The present review attempts to analyze and weigh up this evidence.

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## Effect of nuts on body weight

Dietary fat has been repeatedly involved in the development and maintenance of obesity, although there is considerable controversy on this issue. Nevertheless, since nuts are rich in fat, their potential effect on body weight has generated some concern.

Epidemiological studies did not support this concern. In a cross-sectional study performed on 777 school girls, no difference in body weight was observed across categories of nut consumption (Soriguer *et al*, 1995). Similarly, in a large cohort of women, body mass index (BMI) decreased slightly as nut consumption increased. After a 16-y follow up and adjustment for several potential confounders, average weight gain across categories of nut consumption was not significantly different (Jiang *et al*, 2002).

An analysis of intervention studies performed with nuts shows similar findings. Most of these trials showed no significant changes in body weight associated with nut-rich diets (Table 1). These studies, however, were not designed to evaluate body weight and some of them controlled total energy intake, which made it difficult to draw any firm conclusions. This difficulty is compounded by the heterogeneous design of these studies, which provided variable amounts of total fat (26–43%), monounsaturated fat (6–28%) and polyunsaturated fat (2–17%). In addition, whereas some

**Table 1** Recent human intervention studies with nuts reporting data on body weight

| *Author* | *Subjects* | *Nut intervention* | *Duration (weeks)* | *Body weight change* | *Type of study* | *Comments* |
|---|---|---|---|---|---|---|
| Jenkins *et al* (1997) | 10 healthy BMI $23\pm1$ kg/m$^2$ | Diet high in vegetables, fruit and nuts (60–120 g/days) | 2 | No change | Randomized crossover | Diet was controlled |
| Spiller *et al* (1998) | 45 hyperlipidemic BW $66\pm13$ kg | 450 kcal of almonds (100 g/day) plus baseline diet | 4 | No change | Randomized controlled, parallel | ~630 kcal was added to the diet. Dietary advice was given |
| Edwards *et al* (1999) | 10 hypercholesterolemic BW 50–102 kg | Pistachio nuts substituting 20% of daily caloric intake | 3 | No change | Randomized controlled, crossover | No change in EI or fat intake |
| Zambón *et al* (2000) | 49 dyslipidemic BMI $27.0\pm3.1$ kg/m$^2$ | 41–56 g/day of walnuts replacing 35% of energy from monounsaturated fat | 6 | No change | Randomized crossover | Diet was controlled |
| Morgan and Clayshutte (2000) | 10 normolipemic BMI $24\pm5$ kg/m$^2$ | 68 g pecans/day plus self-selected diet | 8 | No change | Randomized, controlled parallel | Pecan consumption increased EI by 20% |
| Curb *et al* (2000) | 34 subjects 80–130% of ideal BW | Macadamia nuts (37% energy from fat) | 4 | No change | Randomized controlled, crossover | Meals were provided. Daily intake of macadamia nuts not specified |
| Almario *et al* (2001) | 23 dyslipidemic BMI $29\pm1$ and $28\pm1$ kg/m$^2$ | 48 g walnuts plus habitual diet or low fat diet | 6 | No change | Not randomized | Increase in EI by 1661 and 1514 kJ/day and fat intake in both groups |
| Hyson *et al* (2002) | 22 normolipemic BMI $23.7\pm1.2$ kg/m$^2$ | Almonds substituting 50% of fat intake (average 66 g almonds/day) | 12 | No change | Randomized controlled, crossover | Diet was controlled. No increase in EI |
| Morgan *et al* (2002) | 42 hyperlipidemic BMI $27.7\pm5.8$ kg/m$^2$ | 64 g walnuts/day plus low-fat diet | 6 | No change | Randomized crossover | Increase in unsaturated fat intake (12%) and total energy (1.2 MJ) |
| Jenkins *et al* (2002) | 27 hyperlipidemic BMI: 20.5–31.5 kg/m$^2$ | Almonds as a supplement providing 22% of energy (73 g/day) | 4 | No change | Randomized crossover | No increase in energy or fat intake |
| Iwamoto *et al* (2002) | 40 healthy subjects | Walnuts 44–58 g (12.5% of total energy) plus usual Japanese diet | 4 | No change | Crossover | All meals were provided and controlled |
| Fraser *et al* (2002) | 81 subjects BMI $26.7\pm3.6$ kg/m$^2$ | Free supplement of almonds (around 76 kJ) | 24 | No change | Randomized crossover | No dietary advice was given |
| Lovejoy *et al* (2002) | 20 healthy BMI 18–30 kg/m$^2$ | Supplement of 100 g almonds/day plus habitual diet | 4 | Increase 0.9 kg in men and 0.3 kg in women | Noncontrolled | Increase in EI and unsaturated fat intake |

BW: body weight; BMI: Body mass index; EI: Energy intake.

reports evaluated the specific effects of particular nuts, others only included nut consumption to modify the fatty acid profile of the diet.

In spite of these considerations, these studies show that when nuts are consumed as a replacement food, there is no net weight gain. More striking is the fact that some studies found that when nuts are added to the diet, there is no associated increase in body weight even when total energy intake is substantially greater (Morgan & Clayshulte, 2000; Morgan *et al*, 2002). For example, adding 48 g of walnuts to the diet for 6 weeks did not increase weight although energy intake increased by 1661 kJ/day (Almario *et al*, 2001). The duration of the nut intervention in these trials is relatively short, however, and gives no indication of the impact of nut intake in the long-term. Only one intervention study has shown a negative effect on body weight. In this study of normal-weight subjects, adding 100 g of almonds per day to the usual diet for 4 weeks led to a slight but significant increase in body weight (0.9 kg for men, 0.3 kg for women) (Lovejoy *et al*, 2002).

To date, only one study has specifically evaluated the role of nuts on body weight. In this crossover study, 81 subjects consumed a free daily supplement of almonds (about 15% of each individual's daily energy) for 6 months. Subjects did not receive dietary advice, and no significant change in body weight or waist/hip ratio was found. Only those subjects in the lowest BMI tertile showed any indication of weight gain, whereas the most obese subjects actually lost small amounts of weight. A significant inverse association was observed between baseline BMI and change in weight (Fraser *et al*, 2002). A promising discovery about the role of nuts in body weight regulation has been presented recently. McManus *et al* (2001) compared the efficacy of a Mediterranean-style diet (rich in nuts and moderate in fat, 35% of the daily energy) and a standard low-fat diet (20% of the daily energy) for weight loss in 101 overweight adults. At the end of the 18-month trial, the moderate-fat group showed a decrease in body weight and waist circumference, whereas the low-fat group regained weight progressively. The difference in weight change between the groups was 7.0 kg ($P<0.001$) and after 2 1/2 y the moderate-fat group still weighed significantly less. Of particular note is that the participation rate was higher in the moderate-fat group than in the low-fat group at all times. Hence, the Mediterranean-style diet, rich in nuts, seems to be an attractive alternative to a standard low-fat diet with greater long-term participation and adherence, and improvements in weight loss (McManus *et al*, 2001).

Hence, most of the evidence suggest that although nuts are fatty and high-energy foods, they do not lead to weight gain. On the strength of present evidence, this apparent contradiction cannot be solved but some hypotheses can be put forward:

- The absorption of energy from nuts is incomplete. Five healthy subjects consuming 76 g of peanuts for 4–6 days excreted 18% of dietary fat per day and the stools contained intact portions of the nuts, which, therefore, were not available for lipid digestion. This fat malabsorption was observed both when high and low-fiber diets containing whole peanuts were evaluated (Levine & Silvis, 1980). Similarly, a 4-week diet rich in pecans significantly increased the excretion and percentage of stool fat compared to a nut-free diet. In this study, subjects consuming pecans required more energy to keep their body weight stable (Haddad & Sabate, 2000). This low level of fat absorption may be due to the structure of lipid-storing granules in nuts or to various nut fiber components.
- Some authors suggest that nuts exert some kind of satiating effect. In a 6-month clinical trial, Fraser *et al,* (2002) demonstrated that between 54 and 78% of the extra energy provided by an almond supplement was displaced by reductions in the intake of other foods. Theoretically, this effect can be attributed to such components as dietary fiber, whose role in energy intake has been discussed at length (Marlett *et al*, 2002).
- Finally, the particular composition of nuts can affect energy metabolism in such a way that it compensates for the increase in energy availability. Animal and human studies have shown higher diet-induced thermogenesis, higher fat oxidation and less body fat accumulation with unsaturated fat consumption compared to saturated fat intake (Jones *et al*, 1992; Takeuchi *et al*, 1995). Resting energy expenditure increase by 11% after regular peanut consumption for 19 weeks (Alper & Mattes, 2002). However, no change in resting energy expenditure or respiratory quotient was observed in subjects consuming a supplement of almonds for 6 months (Fraser *et al*, 2002).

## Effects of nuts on glucose metabolism

High-fat diets have been associated with a detrimental effect on glucose homeostasis in epidemiological and intervention studies (Mayer-Davis *et al*, 1997). There is little evidence on the role of nuts, but it seems that, despite being rich in fat, they do not negatively affect glucose homeostasis. Administering 100 g almonds/day for 4 weeks to 20 healthy subjects following their habitual diets led to no associated changes in insulin sensitivity (Lovejoy *et al*, 2002). Similarly, consumption of 57–113 g almonds/day for 4 weeks had no effect on fasting and postprandial glucose or insulin concentrations, or $HbA_{1c}$ levels in type II diabetic patients, suggesting that the addition of almonds has no detrimental effect on glycemic control (Lovejoy *et al*, 2002).

In recent years, unsaturated fat intake has been associated with a lower risk of type II diabetes (Meyer *et al*, 2001) and improved glycemic control in diabetic patients (Garg *et al*, 1994). Since nuts are rich in unsaturated fats, they may have a beneficial effect on glucose homeostasis. In addition, some components of nuts such as fiber or magnesium have been inversely associated with the risk of type II diabetes (Marlett *et al*, 2002). There is very little evidence to support this hypothesis to date, however. In a large prospective trial performed with 83 818 women over a 16-y period, nut consumption was inversely associated with the risk of developing type II diabetes. This protective effect persisted after adjustment for possible confounders and was maintained for all subgroup analyses (Jiang *et al*, 2002).

## Conclusion

The current data available indicate that free-living people on self-selected diets that include nuts do not have a higher BMI or a tendency to increase body weight. Similarly, the results from healthy and diabetic subjects did not support a negative effect of nut consumption on glucose homeostasis. These observations and the well-demonstrated beneficial effects of nuts on cardiovascular health show that nuts can be included in diets to meet energy needs. However, longer intervention studies are needed to prove the innocuity of nut consumption in the long term. Furthermore, there is some intriguing, although very limited, evidence that nuts can help to regulate body weight and protect against type II diabetes. This, however, still has to be proved and more research is needed to address the specific effects of nuts on satiety, energy balance, body weight and insulin resistance. It is important to remember, however, that nuts are complex foods and evaluating their effect only from the point of view of their fatty acid composition is a very limited approach. Nuts include other components, such as fiber or calcium, which may have an effect on body weight regulation and insulin sensitivity. So, more work is needed to evaluate the variety of mechanisms that are regulated by the components of nuts and which may exert these effects.

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