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Nutraceuticals and Weight Management

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CHAPTER 15

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Gwendolyn W. Pla

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INTRODUCTION

Obesity and being overweight are significant risks to health for adults and children. Both overweight and obesity are estimated by calculation of the body mass index (BMI). BMI is the ratio of weight to height and represents the degree of body fatness. Although the BMI does not actually measure body fat, there is a good correlation between body fat and BMI.

HEALTH CONSEQUENCES OF OVERWEIGHT AND OBESITY

The health consequences of overweight and obesity include the following: (1) premature death, because obese individuals have a greater than 50% risk of death...
than do those of a healthy weight; (2) risks of heart disease, including congestive heart failure, angina, sudden cardiac death, and abnormal heart rhythm are increased for individuals whose BMI is above 25; (3) increased risk of certain cancers, including endometrial, colon, gall bladder, prostate, kidney, and breast; (4) sleep apnea; (5) arthritis; and (6) reproductive complications. A weight gain of 11–18 lb doubles the risk of type 2 diabetes mellitus (DM), and more than 80% of the people with type 2 DM are overweight or obese. Other health consequences include gall bladder disease, incontinence, increased surgical risk, and depression. In children and adolescents, social stigma and depression can also occur [Office of the Surgeon General of the United States 2007].

Overweight children and adolescents are likely to be at risk for hypertension, elevated cholesterol, and type 2 DM. Until recently, type 2 DM was called adult-onset diabetes and was rarely seen in persons under 40 years of age. Type 2 DM is on the rise in children and adolescents and, as in adults, has been linked to overweight and obesity. Additionally, overweight children are likely to become overweight adults.

**PREVALENCE OF OBESITY**

According to data from the most recent National Health and Nutrition Examination Survey, the National Center for Health Statistics found that, in adults aged 20–74 years, the prevalence of obesity increased from 15% in 1976–1980 to 34% in 2005–2006. Among children and adolescents, ages 2–19 years, the prevalence of obesity in 2005–2006 was 16%. These children were at or above the 95th percentile of the 2000 BMI for age growth charts. Also, in children and adolescents, the prevalence of being overweight increased from 5 to 13.9% in children ages 2–5 years, from 6.5 to 18.8% in children ages 6–11 years, and from 5 to 17.4% in children ages 12–19 years. Furthermore, 31.9% of children ages 2–19 are above the 85th percentile of the 2000 BMI for age growth charts [Centers for Disease Control and Prevention 2008].

As in the United States, the prevalence of obesity is growing worldwide. Pain [2007] notes that obesity is a problem in both developed and developing countries and that starvation, malnutrition, and obesity can all coexist in developing countries as some members of the population become more affluent. Also, the prevalence of obesity in Europe has quadrupled in the past 10 years, from 10 to 40%.

**PREVENTION AND TREATMENT**

Effective means of prevention and treatment of obesity and overweight remain elusive. Treatment, historically, has focused on reliance on a number of different kinds of diets, including very low-calorie diets, low-calorie diets, diet and exercise programs, pharmaceuticals, surgery, and behavior modification programs [Bray 1998]. Nutraceuticals and functional foods are receiving considerable interest for their role in improving health status, including weight problems and fat...
distribution. The term nutraceutical comes from a merger of the terms nutrition and pharmaceutical. These are foods or parts of food that have been shown to convey health benefits. If a functional food is used in the prevention or treatment of disease, it is considered a nutraceutical [Kalra 2003]. Nutraceuticals may be naturally occurring or added as supplements. The term functional foods, which originated in Japan in the 1980s, refers to foods that provide nutrients as well as other substances that promote health. They come from both plant and animal sources [Hasler 1998].

A number of reports have been published on the actions of various food components, including nutrients, and herbs on body weight and fat distribution, on fat free mass and metabolic rate. This paper will discuss some of the scientific findings regarding the use of nutraceuticals and functional foods for reduction of body fat and body weight and body fat distribution.

**SELECTED NUTRACEUTICALS REPORTED TO INFLUENCE BODY FAT AND BODY WEIGHT**

**Chromium**

Trivalent chromium is an essential nutrient, needed for carbohydrate and fat metabolism, that is found in numerous food sources, including beef, liver, eggs, chicken, brewer’s yeast, oysters, wheat germ, green peppers, apples, bananas, and spinach. Despite the widespread availability of chromium in the food supply, Preuss and Anderson [1998] and Anderson [1997] suggest that the majority of people consume less than adequate chromium. Chromium supplementation improves insulin function in diabetics and has been investigated for reduction in body fat and for retention of lean body mass. Novel chromium complexes, chromium picolinate, and niacin bound chromium (NBC), have been investigated for their effects on body weight and body fat distribution. In 2003, Vincent reported the results of a review that found no effect of chromium picolinate on body mass or composition [Vincent 2003]. Other reports have found chromium picolinate to be associated with weight gain [Bagchi 2007]. NBC has been shown to be efficacious in improving body composition and weight status in overweight and obese subjects when combined with a reduced calorie diet and exercise regimen. Reduced food intake has also been observed. NBC was shown to improve body fat loss but retain lean body mass. Additionally, NBC has been found to have the greatest bioavailability compared with other novel chromium compounds. A meta-analysis of 10 studies of chromium picolinate on weight loss in overweight to obese subjects found that, with energy restriction of 3,300 kJ (788 kcal), the amount of weight lost was 1.5–2.5 kg (3.3–5.5 lb)/week, and, at more moderate energy restriction, 5,000 kJ (1194 kcal)/day, the amount of weight reduction was 0.5–0.6 kg (1.1–1.3 lbs/week [Pittler and Ernst 2004]). Regarding safety, chromium picolinate has been found to have mutagenic potential in laboratory animals. No negative safety effects have been associated with NBC [National Institutes of Health/Office of Dietary Supplements].
Conjugated Linoleic Acid

CLA is a family of isomers of linoleic acid, each having different functions. One has anticarcinogenic, antiobesity, and antidiabetic effects; another has anticancer effects. As an antiobesity agent, CLA is believed to act by decreasing food and energy intakes, decreasing lipogenesis, and increasing fat oxidation, lipolysis, and energy expenditure. They are found in dairy products associated with the fat fraction and in ruminant animals, such as beef and lamb. There are also synthetic mixtures [Kong 2007]. Gaullier et al. [2007] reported that CLA was found to be effective in reducing fat mass in the abdomen and legs of overweight and obese women. However, other studies have found no such effects. For example, Lamarche and Desroches [2004] reported that CLA-enriched butter had no effect on body fat distribution in men. Kong [2007] noted that CLA has consistently been shown to “decrease body fat accumulation and increase muscle mass” in several experimental animals, but the results from human trials have not been consistent. Wang and Jones [2004] concluded, after a review of the data of several studies, that the effect on weight and fat accumulation was determined by the particular isomer used and the amount given. In one study, the diet composition (e.g., high-fat versus low-fat diets) was important; greater reductions in weight gain were seen with high-fat diets compared with low-fat diets. However, the effect diminished over time, disappearing by the 12th week. In another study, there was no significant relationship between diet composition and CLA. The results of another study in which a dose of 0.5% decreased fat pad weights in lean rats but the same dose increased fat pad weight in obese rats, led the authors to suspect an animal genotype effect. In most of the studies reviewed, total body fat was reported to be diminished and body protein increased, with the exception of one study in which a decrease of body protein was reported. Despite the favorable effects reported in some studies, there were also some adverse events in some of the studies. The adverse events that were reported were hyperinsulinemia and fatty livers and spleens. These raise safety concerns.

A meta-analysis of 20 human studies of randomized, longitudinal, double-blind studies with a control group was reported by Whigham et al. [2007]. The studies that were examined included normal weight, overweight, and obese subjects with information on type of isomer used and dosage. Given that animal studies identified the \( t_{10}, c_{12} \) as the isomer with the largest effect on body fat, they did not include the treatment groups that only received \( c_{9}, t_{11} \) CLA isomers. Only those studies of effect of CLA (\( t_{10}, c_{12} \)) on body fat with validated body composition techniques were included. On the basis of the meta-analysis, it was determined that there is a small but significant effect of CLA (\( t_{10}, c_{12} \)) on body fat.

Combined Effects of Chromium Picolinate and CLA

The combined effects of chromium picolinate and CLA have been examined in human and animal studies. For example, Diaz et al. [2008] studied the combined effects of chromium picolinate and CLA on changes in the body composition of overweight women who were on energy restricted diets and exercise regimens. They
reported no effect of this combination on body composition. In a previous report, Bhattacharya et al. [2006] found that the combination of chromium and CLA did decrease body weight and fat mass in mice fed a high-fat diet.

**Calcium**

This essential mineral is needed for many functions, including bone formation and integrity, blood clotting, muscle contraction, transmission of nerve impulses, and the action of several enzymes.

There has been a lot of interest in calcium as a nutrient to modulate body weight. Numerous reports from animal and human studies regarding effects of calcium supplementation from dairy products and from calcium supplements have been inconsistent. A number of studies have reported an association of calcium supplementation with reduction in body fat. Others have shown no such effects [Dwyer 2005]. Trowman et al. [2006] conducted a systematic review of the literature and subsequent meta-analysis of trials involving calcium supplementation using calcium supplements or dairy products in persons ages 18 years or older. They concluded that there is no significant benefit of calcium supplementation on body weight. However, they found that some of the studies had flaws in the randomization process, which could affect the results. Gonzalez et al. [2006] reported the results of a study in which retrospective data were used to assess a calcium intake-weight change relationship over an 8- to 10-year period. Women who used supplements gained less weight than those who did not. There were no significant differences in men. They concluded that increased calcium intake may be beneficial to women. Zemel [2007] has reported that isocaloric substitution of three daily servings of dairy products in humans produced an increase in lipolysis. Additionally, it has been demonstrated that a high-calcium diet fed to rats and to mice stimulated a significant increase in fecal fat and energy excretion. A greater antiobesity effect of high-calcium diets was observed in obese mice fed a high-fat diet than in those fed a low-fat diet. In both human and animal studies, a shift in the distribution of body fat was observed. Dairy calcium sources have been shown to be more effective in controlling fat accumulation than supplemental sources of calcium.

Zemel suggested, also, that other bioactive components of dairy products may act independently or synergistically to reduce fat by reducing lipogenesis and increasing lipolysis and lipid oxidation. All of these studies were in animals or adult humans. Moreover, in support of his position of dietary calcium as an antiobesity agent, Zemel proposes a mechanism for this action. The roles of parathyroid hormone and 1,25-(OH)$_2$-D in responding to low-blood calcium are well known. He proposed that dietary calcium suppresses these hormones that favor energy storage to promote energy (fat) loss.

In one study involving children, DeJongh, Binkley, and Specker [2006] examined whether there was an association between change in body fat or in fat mass and total calcium intake in preschool children using data from a previously randomized trial of calcium supplementation. They found no consistent relationship between changes in total percentage body fat or fat mass and total or dietary calcium intake.
Phytoestrogens

Soy protein is a source of isoflavone, a phytoestrogen. Aubertin-Leheudre et al. [2007], in recognition of the many beneficial health effects of the phytoestrogens, conducted a study to investigate whether isoflavone supplementation could affect fat-free mass. They found that supplementation of postmenopausal, obese, sarcopenic women with 70 mg/day isoflavone for six months did significantly increase fat-free mass. This effect is significant because of the relationship of metabolic rate to fat-free mass. Soy protein has been reported to reduce body weight and fat mass in both animals and humans [Valasquez and Bhathena 2007].

Medium-Chain Triglycerides

Medium-chain fatty acids have been used therapeutically since the 1950s for treatment of malabsorption syndromes. Their absorption, solubility, and metabolism differ from long-chain fatty acids. Medium-chain fatty acids, lauric acid, and capric acid are components of coconut oil, palm oil, and milk. Lauric acid is a component of breast milk. The use of coconut oil and palm oil is largely discouraged because of their degree of saturation. However, there are advantages to both. A body of research, recently published, supports the value of coconut oil as an antimicrobial agent [Enig 2007]. Palm oil is a source of antioxidants with some protection against certain cancers [Sundram et al. 2003]. Several studies in the early 1980s found that experimental animals fed medium-chain triglycerides (MCTs) had increased thermogenesis and gained less body weight than those fed long-chain triglycerides (LCTs) [Seaton et al. 1986]. Following these reports, a study was conducted to determine whether metabolic rate could be increased more by a single meal of MCTs than by a single meal of LCTs in adult men. The results indicated that oxygen consumption after the MCT meal increased more than after the LCT meal. Studies comparing effects on body weight and fat distribution in experimental animals have produced different results [Seaton et al. 1986]. St-Onge [2005] reported the results of a study in humans in which energy expenditure from MCTs increased more than it did with LCTs. However, there was a slight variation in the extent to which it occurred. Body weights did not change in women, but there were significant reductions in total adipose tissue, subcutaneous adipose tissue, and upper body adipose tissue in men.

Both animal studies and human studies have shown that MCTs stimulate more diet-induced thermogenesis than LCTs, thus leading to less body fat. This may occur because medium-chain fatty acids are not stored, are oxidized for energy production, raise the body temperature, and use more energy [Enig 2007].

CONCLUSIONS

Overweight and obesity continue to be serious health problems despite the many treatment approaches. As we consider the growing body of literature concerning...
the effectiveness of nutraceutical and functional foods in meeting this challenge of stemming the prevalence of overweight and obesity, we see that there is not widespread agreement among scientists about the effectiveness of these substances. Some of these studies have produced conflicting results, which may be related to the lack of uniformity in study design, composition of nutraceuticals and mode of delivery, duration of the trial, study variables, and experimental models.

Moreover, there are some adverse events that have been reported with many of the nutraceuticals at high levels. It is time to look very carefully for prevention methods, some of which should be designed to cure the environment and to return to eating practices that were common before the obesity epidemic. There appears to be, based on scientific evidence, a need for more consumption of natural products, such as coconut oil, and increased consumption of milk and other dairy products. For consumers who are lactose intolerant, there is lactose-reduced milk. Also, yogurt has calcium as well as probiotics that may convey additional health benefits [National Institutes of Health/National Center for Complementary and Alternative Medicine]. Hill and Peters [1998] discussed environmental conditions that have fueled the explosion of the obesity epidemic. These include easy availability of low-cost foods that are offered in large portions, excessive consumption of high energy foods, often as fat, and low levels of physical activity. They suggested that we “must cure the environment,” by consumer education that would reduce portion sizes, promote fun activities to encourage physical activity in children, increase availability of foods that are more nutrient dense and less energy dense, and provide incentives (e.g., lower-cost health insurance), etc.

The Dietary Guidelines for Americans [U.S. Department of Health and Human Services/U.S. Department of Agriculture 2005] and the diet planning principles [Whitney and Rolfes 2008] give us blueprints for action. It is time for health professionals, families, and communities to improve use of these blueprints.

REFERENCES


