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Brief communication

Macronutrient effects on satiety and binge eating in bulimia nervosa and binge eating disorder☆

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Women with bulimia nervosa (BN) and those with binge eating disorder (BED) have marked disturbances in satiety. For example, they consume greater food intake than controls throughout the day (Rossiter, Agras, Telch, & Bruce, 1992; Weltzin, Hsu, Pollice, & Kaye, 1991) and during binge eating episodes compared to controls asked to binge eat (Hadigan, Walsh, Devlin, LaChaussee, & 1992; Yanovski, Leet, Yanovski, Flood, Gold, Kissileff, & Walsh, 1992). In addition, women with BN report lower satiety after fixed meals than controls (Geracioti & Liddle, 1989). These findings are consistent with disturbances in physiological indices of satiety in these women, such as the blunted release of the satiety agent cholecystokinin following food intake (Geracioti & Liddle, 1989) and the increased gastric capacity (Gelieb-ter, Melton, McCray, Gallagher, Gage, & Hash, 1992) found in women with BN.

Another difference between women with BN or BED and controls is in their dietary selection. Women with these disorders have been found to consume lower proportions of protein during their binge episodes compared to controls asked to binge eat (Walsh, Kissileff, Cassidy, &, Dantzic, 1989; Yanovski et al., 1992). Women with BN also ingest lower proportions of protein during binges compared to their own non-binge episodes (Van der Ster Wallin, Noring, &, Holmgren, 1994), and in the overall diet compared to controls (Hetherington, Altemus, Nelson, Bernat, &, Gold, 1994). Women with BN begin binge episodes with dessert and snack foods, whereas controls begin binges with fish and meat (Hadigan, Kissileff, &, Walsh, 1989).

These abnormalities in dietary selection may have particular significance in light of the different satiating effects of the macronutrients in normal individuals. Protein leads to greater suppression of food intake and greater reported fullness than other macronutrients (Latner & Schwartz, 1999). For example, 12 female college students without eating disorders were given three 450-kcal liquid lunches on non-consecutive days, high-protein (71%), high-carbohydrate (99%), and an equal mixture of these two liquid lunches, in counterbalanced order. Participants were asked to eat as much as they felt like at a buffet-style dinner 4 h later. They consumed 24% less at dinner after protein, and 17% less after the mixture, than after carbohydrate. Greater hunger and excitement about eating before dinner were reported in the carbohydrate lunch condition compared to the protein lunch condition. Greater enjoyment of dinner was reported in the carbohydrate condition compared to the mixture and protein conditions (Latner & Schwartz, 1999). Such short-term findings are consistent with reports that over the long-term, only dietary protein (as a proportion of total energy intake) is inversely correlated with later intake, unlike carbohydrate or fat (DeCastro, 1987).

The satiety deficits in BN and BED might in part be corrected by inducing dietary patterns designed to increase satiety. It would be valuable to discover whether the different satiating effects of the three macronutrients also apply to individuals with eating disorders. The aim of the study was to compare the satiating effects of protein and carbohydrate in women with BN or BED.

To examine this, 18 women (mean age = 34.8) diagnosed with either BED ($n = 11$, mean BMI = 31.1) or BN ($n = 7$, mean BMI = 22.3) were given two 14-day periods of liquid supplements (280 kcal), high-protein (76%) or high-carbo-hydrate (96%) in a repeated-measures, counterbalanced design. Supplements were to be consumed three times each day, one hour prior to typical meal times. They were balanced

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across conditions for appearance, flavor, volume, fiber and sweetness. Participants recorded their food intake and binge eating during an initial baseline week, throughout each of the two weeks of high-protein or high-carbohydrate supplementation, and during a seven day wash-out period between the phases.

On the morning of the final day of each phase, participants were given a 420 kcal high-protein or high-carbohydrate supplement, corresponding with the current phase. Three hours later, participants were served a buffet-style test meal in a private room. Ample portions of foods typical of both meals and binges, varying in macronutrient content and energy density, were offered. Participants were instructed to let themselves eat as much as they felt like eating. Before and after this meal, participants completed visual analogue scales, anchored with the words 'most imaginable' and 'not at all,' assessing their hunger and fullness, and satisfaction. At the end of both phases, participants were asked to compare their levels of hunger, satisfaction, interest in food, temptation to binge, and feelings of sickness across the two phases, on 3-point scales labeled 'no difference,' 'slightly more,' and 'much more' during either phase.

Binge eating episodes, or objective bulimic episodes (OBEs), the consumption of unequivocally large amount of food accompanied by a loss of control over eating, were identified from participants' food records. Binge frequency, food intake at test meals, and hunger and satiety levels before and after these meals, were compared between phases using paired-sample *t*-tests. Binge frequency during each phase was also compared with baseline frequency. Chi-square tests compared participants' reports of hunger, satiation, interest in food, desire to binge, and feelings of sickness across phases.

Binge episodes occurred less frequently during the protein phase (1.19 OBE/week) than during the carbohydrate phase (2.94 OBE/week), $t(17) = 4.58$, $p < 0.001$. During protein supplementation, but not during carbohydrate supplementation, average daily OBE frequency fell below baseline level (3.01 OBE/week), $t(17) = 2.98$, $p < 0.01$. The frequency of subjective bulimic episodes (SBEs), the self-reported loss of control over eating in the absence of the consumption of a large amount of food, did not differ significantly during baseline, protein, or carbohydrate supplementation. A greater weight change occurred during the carbohydrate phase (1.06 kg) than during the protein phase (0.27 kg), $t(17) = 2.92$, $p < 0.01$. Unlike the weight change during protein, the gain during the carbohydrate phase was significantly greater than zero, $t(17) = 3.78$, $p < 0.005$.

Three hours following supplements on the final day of each phase, hunger was lower, $t(17) = 2.32$, $p < 0.05$, and fullness higher, $t(17) = 2.25$, $p < 0.05$, after protein supplements than after carbohydrate supplements. Satisfaction was marginally higher after protein supplements, $t(17) = 2.06$, $p = 0.055$.

At the ad libitum meal, participants consumed less energy (difference: 183 ± 283 kcal) 3 h after protein supplements (673 kcal) than after carbohydrate supplements (856 kcal), $t(17) = 2.75$, $p < 0.02$. There were no significant differences in macronutrient composition or energy density between the meals. Following these meals, there were no differences in participants' reported hunger, fullness, or satisfaction, suggesting that they needed to consume less food after protein than after carbohydrate in order to feel as satiated.

At the end of both phases, 61% of participants reported having felt more hungry during the carbohydrate phase, whereas 17% were hungrier during protein, $\chi^2(2) = 6.33$, $p < 0.05$. Similarly, 61% of participants reported feeling more satiated during the protein phase, compared with 11% during carbohydrate, $\chi^2(2) = 7.00$ $p < 0.05$. Greater temptation to binge was reported by 39% during carbohydrate and 11% during protein, $\chi^2(2) = 6.33$, $p < 0.05$. There were no differences in the proportion of participants in each response category for interest in food or feeling sick. No differences emerged between BN or BED participants for any dependent variables examined.

These results indicate that in women with BN or BED, dietary supplementation with protein substantially decreased binge eating, compared to supplementation with carbohydrate and compared to their baseline binge frequency. Protein supplements also led to greater fullness, lower hunger, and less ad libitum food intake than carbohydrate supplements.

One direction for future research is to examine the physiological mechanisms that mediate protein's effect on satiety. Another direction is to identify other aspects of foods that increase satiety in patients with eating disorders. Findings from such research could inform a longer-term treatment directed at restoring satiety.

Increasing the level of protein in the diet of patients in treatment for BN and BED might help to correct or to compensate for the satiety deficits and abnormalities in macronutrient selection found in these disorders. Such an intervention might also enhance patients' ability to remain on a schedule of regular, controlled meals and snacks over the long-term.

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