Determinants of weight maintenance in women after diet-induced weight reduction.

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Determinants of weight maintenance in women after diet-induced weight reduction

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OBJECTIVE: Assessment of determinants for relatively successful weight maintenance in women after diet-induced weight reduction.
DESIGN: Subjects followed two weight cycles over two years, each cycle starting with a Very Low Energy Diet (VLED) (2.8 MJ/d), in a free-living situation. They completed the Herman Polivy Restraint Questionnaire and the Three Factor Eating Questionnaire twice, that is, before and during the first VLED.
SUBJECTS: Twenty seven obese women, body mass index (BMI) (28–38 kg/m^2), age (19–53 y), being premenopausal and healthy, participated twice in the energy restriction periods with one year follow-up.
MEASUREMENTS: Weight and body composition were measured at weeks 0, 8, 60, 68 and 120 after the start of the first VLED. Scores on the restraint scales before and during the first VLED were analysed. Percentages regain after one year and after two years follow-up were related to these scores.
RESULTS: Three groups appeared with respect to success regarding weight maintenance. Group 1 (successful): twice a regain $<50\%$ of weight loss; group 2 (partly successful): once a regain $<50\%$ of weight loss and group 3 (unsuccessful): twice a regain of $>50\%$ of weight loss. Percentage regain was negatively correlated to an increase in cognitive restrained eating behaviour ($r=0.8$; $P=0.0001$). A change in attitude with respect to food intake, expressed as an increase in cognitive restraint, and as a positive relationship between cognitive restraint and disinhibition was related to successful weight maintenance.
CONCLUSION: An increase in cognitive restraint from before, to during, the diet, and a positive correlation between cognitive restraint and disinhibition, are two determinants representing eating behaviour for successful weight maintenance.

Keywords: weight reduction; weight maintenance; weight regain; dietary restraint; eating behaviour

Introduction

The prevalence of overweight and obesity is not only increasing in the US,[1] but also in Western Europe.[2] Since severe obesity and even mild to moderate overweight are associated with increased risk of coronary heart disease, hypertension, dyslipidaemia and non-insulin-dependent diabetes mellitus (NIDDM),[3–6] prevalence figures for overweight and obesity are alarming. Voluntary weight loss efforts have been shown not to be effective for treatment of obesity in the long term[7–9] and many obese people have a long history of dieting often with successful weight losses, but also disappointing relapses. Accurate information on prevalence and magnitude of weight fluctuations is currently unknown, but estimates indicate that one out of three obese adults and 53% of overweight adults in the US are trying to lose weight.[9]

A pattern of repeated weight loss and regain, or weight cycling, may lead to metabolic adaptations that hamper subsequent efforts of weight loss and maintenance of reduced weight.[10,11] Moreover, variability in body weight may increase the risk of overall and cardiovascular mortality, as is indicated by epidemiological studies,[12–14] but the scientific debate about potential metabolic and health effects of weight cycling has not yet ended.[15–18]

Since weight cycling seems to affect metabolic factors,[19–25] it might be possible to predict successful dieting or weight cycling from possible changes in metabolic factors, such as variables reflecting aerobic fitness, energy expenditure, sympathetic nervous system activity, lipolysis, insulin sensitivity and fat oxidation. Several of these variables appeared to be predictive for fat loss during a Very Low Energy Diet (VLED),[26,27] but until now, they were not useful with respect to prediction of weight cycling or weight maintenance.

Apart from these metabolic factors, eating behaviour might be one of the determinants to predict prevention or promotion of weight gain after a weight reduction programme. Eating behaviour with respect to dieting can be characterized using questionnaires, like the Herman-Polivy[28] restrained eating questionnaire, and the Three Factor Eating Questionnaire (TFEQ) by Stunkard and Messick.[29,30] Differences between these methods to measure dietary restraint are as much conceptual as psychometric.

The Herman-Polivy restraint scale measures the extent to which people display concern with their weight and diet chronically to control it.[31] In the Herman-Polivy restraint construct, disinhibition of

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restraint is measured implicitly. Relatively high scores on the Herman-Polivy restraint questionnaire are observed in the obese, and these scores correlate positively with body mass index (BMI).[30] The first question in this questionnaire: 'How often are you dieting?' and the following questions specifying the first question, imply a relationship with failure of weight maintenance. The obese restrained eaters restrict their food intake because of being weight conscious,[30] but without much success.[28,32,33]

The TFEQ does not appear to measure the same behavioural tendencies as the Herman-Polivy restraint scale, but discriminates between successful energy intake restriction and disinhibition of restraint. In the TFEQ, pure restraint without disinhibition is measured as cognitive restraint. Disinhibition is measured separately. In the obese, the factors of cognitive restraint and disinhibition of the TFEQ are relatively high and correlated negatively, which indicates that they alternate restrained and disinhibited eating behaviour and consequently are vulnerable to weight cycling.[34]

Normal weight restrained eaters are successful in keeping their weight at a certain level for a relatively long time, by maintaining a low energy intake in relation to a relatively low energy expenditure.[35] Their relatively low scores on the Herman-Polivy restraint scale indicate that they are relatively less weight concerned[30,32] and their relatively high scores on the cognitive restraint factor (TFEQ),[29] reflect that they are mainly food concerned. Their cognitive restraint scores and H-P scores do not show mutual correlations nor any correlations with BMI.[30] In these subjects, cognitive restraint and disinhibition scores of the TFEQ are correlated positively, indicating that they perform restrained eating behaviour and disinhibition of restraint at the same time,[34] and thus are more flexible than the overweight dietary restrained subjects.

Thus, the Herman-Polivy restraint scale is designed to identify dieters, whereas the TFEQ is designed to measure successful dieting.[32]

From the observation that food consciousness seems a successful strategy in the normal weight dietary restraint women, we hypothesized that cognitive dietary restraint promotes success in the obese when they start dieting. In order to test this hypothesis we offered both questionnaires (Herman-Polivy restraint and the TFEQ) twice to 27 women who represented a sub-sample, taken at random, of 42 obese women who participated in a weight cycling project.[26,36] This weight cycling project consisted of two cycles over 120 weeks. Every cycle started with a VLED of on average 2.8 MJ solidus d.

Methods

Subjects

In total, 57 obese women were recruited by advertisements in local newspapers. Selection criteria were BMI (28–38 kg/m^2), age (19–53 y), being premenopausal and apparently healthy as evaluated by a medical history and physical examination. They did not use any type of medication, and none of them reported to have been on an energy restricted diet in the 6 months prior to the study. Written informed consent was given, and the study was approved by the Medical Ethical Comittee of the University. They participated in an energy restriction period with one year follow-up; 42 of the 57 subjects were willing to participate in a second energy restriction period; 27 of them took part in the second year follow-up. Subjects dropped out for several reasons, for example pregnancy, medical surgery, removal to another place or not having enough time any more. Table 1 gives the characteristics of the 27 subjects who fulfilled two complete cycles, and of the 30 subjects who dropped out.

Procedure

The study lasted 120 weeks and consisted of a controlled dietary weight loss intervention of eight weeks, a non-controlled follow-up of 52 weeks, a second dietary weight loss intervention of eight weeks and a second non-controlled follow-up of 52 weeks.

The subjects ($n=27$) twice followed an energy restriction programme for eight weeks, which was divided into two parts. The first period of four weeks consisted of a low-energy formula diet (Modifast, Sandoz Nutrition, Bern, Switzerland) containing 2.0 MJ/d. It provided 50 g carbohydrates, 52 g protein, 7 g fat and a micronutrient content which meets the Dutch recommended daily allowance. In the second four weeks, subjects were prescribed a mixed diet of 3.5 MJ/d, containing 1.4 MJ of the formula diet supplemented to 3.5 MJ by a free choice from different food items. During the whole eight-week energy restriction period, subjects had to record their daily food intake. Beforehand they were instructed on how to complete a food intake diary. Subjects were also asked to keep their daily activity pattern. During the energy restriction period the subjects came to the

Table 1 Subject characteristics before the start of the study (week 0), means ± s.e.m.

Characteristics	*A* *(n=27)*	*B* *(n=30)*
Body weight (kg)	85.9 ± 1.8	87.1 ± 1.9
Body mass index (kg/m^2)	31.7 ± 0.5	31.2 ± 0.4
Percentage body fat (%)	42.0 ± 0.9	41.8 ± 0.9
Fat mass (kg)	36.6 ± 1.3	36.4 ± 1.2
Fat free mass (kg)	49.7 ± 0.9	50.7 ± 0.9
Waist-hip ratio	0.83 ± 0.01	0.82 ± 0.03
Sagittal diameter (cm)	22.1 ± 0.5	22.0 ± 0.8
F1 (cognitive restraint, means ± s.d.)	10 ± 2	11 ± 3
F2 (disinhibition, means ± s.d.)	8 ± 3	9 ± 4
Herman-Polivy restraint (means ± s.d.)	20 ± 3	20 ± 4

A: the sub-sample of 27 women, who completed two cycles.
B: the sub-sample of 30 women who dropped out during the first VLED.
There are no significant differences between the two groups.

laboratory once a week to have their weight measured and food records checked.

Body weight and body composition were measured before the start of the study (Table 1), at week 8 (immediately after the energy restriction period), at week 60 (one year after the energy restriction period), at week 68 (immediately after the second energy restriction period) and at week 120 (one year after the second energy restriction period). The subjects completed a Dutch translation of the Herman-Polivy restraint questionnaire and of the TFEQ, before (Table 1) and at the end of the first energy restriction period.

No directives regarding diet or physical activity were given for both follow-up periods.

Data analysis

The data with respect to measurements of body weight, body size and body composition were averaged over the subjects. The data of week 8 compared to week 0, and week 68 compared to week 60 were analyzed in order to evaluate dieting effects. The data of week 60 and week 120 were compared to those of week 0, to analyze weight cycling effects.

Because body weight loss during the first energy restricted diet was almost the same for each individual (on average 10 ± 0.4 kg), with a relatively small standard deviation and a range of 8–12 kg, calculating the percentage regain as follows: weight regain/weight loss $\times$ 100%, gives comparable values with a similar meaning. Thus three groups appeared, (1) subjects showing $< 50\%$ weight regain during both follow-up times, or (2) $> 50\%$ weight regain both times or (3) $< 50\%$ during one follow-up and $> 50\%$ weight regain at the other follow-up. The subjects completed the Herman-Polivy restraint questionnaire and the TFEQ before and at the end of the first energy restriction period. The scores and the possible changes in scores on the two questionnaires of these three groups were compared using factorial ANOVA. Possible relationships between the scores for factors of cognitive restraint and disinhibition of the TFEQ, were assessed by a regression analysis. The possible relationship between change in scores on the two questionnaires from the first to the second time and percentage weight regain, was also assessed using a regression analysis.

Results

The effect of dieting appears clearly from the comparison of the average body weight, fat distribution and body composition parameters between week 8 and week 0, respectively and between week 68 and week 60 (Table 2). Body fat percentage, fat mass, fat-free mass, and sagittal diameter decreased in response to the two diets. At the end of both follow-up periods, fat-free mass was no longer statistically significant different from values at week 0.Weight loss during the first energy restricted diet was 10.7 ± 0.4 kg, range 8–12 kg[36] and during the second 6.3 ± 0.6 kg, (both times $P < 0.001$). The effect of weight cycling appeared as a weight regain of 6.0 ± 1.2 kg the first time, and 6.2 ± 0.9 kg the second time. Consequently, the mean value of body weight was significantly lower at week 120 compared to week 0 (81.8 ± 2.4 *vs* 85.9 ± 1.8 kg, respectively, $P = 0.001$).

Table 3 shows that seven subjects had a percentage weight regain of $< 50\%$ twice, eight had a percentage weight regain of $> 50\%$ once, and $< 50\%$ once, and 12 had a percentage weight regain of $> 50\%$, on both occasions.

The scores on the Herman-Polivy questionnaire and on the TFEQ (Table 4), reveal no differences between the three groups. In the three groups, cognitive restraint scores were relatively high, being the lowest in the successful group (cf.[34]). Also, disinhibition scores were high in the three groups (cf.[34]). Changes in cognitive restraint scores (Table 4) were significantly different between the three groups [$F(2.26) = 140.7$; $P < 0.0001$].

In the so-called successful group, the cognitive restraint score increased significantly from before to during the VLED ($P < 0.01$). There was a negative relationship between the change in cognitive restraint and the average percentage regain of two periods, over the whole group ($r = 0.8$; $P = 0.0001$), over the successful group ($r = 0.9$; $P = 0.002$), over the partly

Table 2 Body weight, body composition and body size variables of 27 obese females at week 0, 8 (after first VLED), 60 (after first follow-up), 68 (after second VLED), 120 (after second follow-up) of the study

Variables	*week 0*	*week 8*	*week 60*	*week 68*	*week 120*	*ANOVA***
						0,60,120
Body weight (kg)	85.9 ± 1.8	75.2 ± 1.7*	81.2 ± 2.4	75.0 ± 2.2*	81.8 ± 2.4	$P < 0.001$
Percentage body fat (%)	42.0 ± 0.9	36.6 ± 1.0*	39.2 ± 1.3	$36.1 + 1.3$*	39.2 ± 1.2	$P < 0.005$
Fat mass (kg)	36.6 ± 1.3	27.8 ± 1.3*	32.4 ± 1.9	27.5 ± 1.7*	32.3 ± 1.8	$P < 0.005$
Fat free mass (kg)	49.7 ± 0.9	47.7 ± 0.89*	48.9 ± 1.0	47.5 ± 0.9*	48.8 ± 0.9	$P = 0.12$
Waist-hip ratio	0.83 ± 0.01	0.81 ± 0.01	0.83 ± 0.01	0.82 ± 0.01	0.83 ± 0.01	$P = 0.86$
Sagittal diameter (cm)	22.1 ± 0.5	18.8 ± 0.5*	21.0 ± 0.7	18.2 ± 0.5*	20.7 ± 0.7	$P < 0.005$

VLED = very low energy diet.
Values are means $\pm$ s.e.m. Statistical significance was determined by an analysis of variance for repeated measures (ANOVA). Values of week 0, 8, 60, 68 are included in the analysis to demonstrate diet effects: $P < 0.05$, for comparisons between *week 8 and 0, and *week 68 and 60. Values of **week 0, 60, 120 are included to analyze weight cycling effects.[36]

Table 3 Results with respect to body weight loss and body weight regain ($n=27$) for the three groups: successful ($n=7$, twice a $<50\%$ regain); partly successful ($n=8$, once a $<50\%$ regain; once a $>50\%$ regain); unsuccessful ($n=12$, twice a $>50\%$ regain). Values are means ± s.e.m.

n	*Body weight at the start (kg)*	*BMI*	*Weight loss (1st)*	*% regain*	*Weight loss (2nd)*	*% regain*	*Final body weight*
7 (successful)	82.2±1.7	31.5±0.5	11.3±0.4	32±4	6.2±0.4	38±2	70.7±1.6
8 (partly successful)	87.3±1.9	31.7±0.6	11.1±0.2	57±4	6.4±0.3	87±6	81.7±1.7
12 (unsuccessful)	87.2±1.8	31.8±0.5	9.9±0.3	99±2	6.3±0.4	121±4	88.1±1.9

BMI = body mass index.

Table 4 Scores on the cognitive restraint factor and on the factor disinhibition of the Three Factor Eating Questionnaire and the Herman-Polivy Restraint Questionnaire before and during the first VLED ($n=27$) divided after degree of success (Table 3)

	Cognitive restraint		*Disinhibition*		*Herman-Polivy score*	
	before	*during*	*before*	*during*	*before*	*during*
Successful	8±2	16±2*	7±2	7±2	18±2	19±2
Partly successful	10±2	13±3	8±2	8±3	20±3	20±3
Unsuccessful	11±2	11±3	9±2	9±3	20±3	20±2

*$P<0.01$ compared to cognitive restraint before VLED.
Cognitive restraint: >9; Herman-Polivy restraint: H-P > 15[30]; Disinhibiton: >6[30].
VLED = very low energy diet.

successful group ($r=0.7$; $P=0.02$), but not in the unsuccessful group ($r=0.3$; $P=0.49$). In the successful group, cognitive restraint and disinhibition scores before the diet were positively correlated ($r=0.87$; $P=0.0048$), as well as during the diet ($r=0.82$; $P=0.013$). In the partly successful group, cognitive restraint and disinhibition scores were not correlated ($P=0.21$), and in the unsuccessful group, cognitive restraint and disinhibition scores were negatively correlated before the diet ($r=0.75$; $P=0.032$), and not correlated during the diet. Also in the drop-out group, cognitive restraint and disinhibition scores were negatively correlated ($r=0.68$; $P=0.041$).

Discussion

From the lack of a positive correlation between cognitive dietary restraint and success of dieting, we may conclude that it remains impossible to predict failure or success of dieting from scores on the cognitive restraint factor before a diet starts. So our hypothesis, that highly cognitively restrained eaters would be successful dieters, was not confirmed by these observations. Apparently cognitive dietary restraint has a different effect on obese women, compared to normal weight women.

During the VLED, the average scores on the cognitive restraint factor did not change in the unsuccessful group, indicating that the subjects hardly showed a change in attitude towards eating. Their disinhibition scores and cognitive restraint scores were correlated negatively, as we found before,[30] indicating alternating periods of restraint with periods of relapse, or there were no correlations between cognitive restraint and disinhibition. Also, the drop-outs showed a negative correlation between their original cognitive restraint and disinhibition scores, which values were both relatively high. This indicates, that although the subjects dropped out for various reasons that had nothing to do with this study, for example, pregnancy, medical surgery, removal to an other place, or not having enough time any more, they were likely to be partly successful or unsuccessful. The initial body weight of the partly successful group, the unsuccessful group and of the drop-outs was slightly, but not-significantly higher than that of the successful group, but the BMI's did not differ significantly. Moreover, the subject characteristics of the 27 subjects who fulfilled two complete cycles, and of the 30 subjects who dropped out, did not differ.

A behavioural change with respect to dietary restraint, observed as an increase in the average score on cognitive restraint, during the VLED, was shown mainly in the group that was successful, with respect to weight regain, and less strongly present in the partly successful group. The increase in cognitive restraint score was negatively correlated with percentage weight regain. This change in cognitive dietary restraint was related to weight maintenance to a certain extent, that is twice, or once a regain of $<50\%$ of body weight. Here, we should notice that the scores on cognitive restraint, were not extremely high before the VLED, so it was possible for these subjects to still increase cognitive dietary restraint. Also, their disinhibition scores were relatively low, and they were positively correlated with their cognitive restraint scores, indicating that they allowed disinhibition of restraint occasionally.

In this respect, Westenhoefer and co-workers,[37,38] report that rigid control of eating behaviour is associated with increased disinhibition or susceptibility scores and with high cognitive restraint scores. This might coincide with the differences between the successful and unsuccessful group. Our successful group also seems to be more flexible with respect to eating behaviour, but we expressed this flexibility by an increase in cognitive restraint, related, within the group, positively to disinhibition. Our unsuccessful group showed a more rigid control of eating behaviour, by relatively high, but unchanged, values of cognitive restraint, related, within the group, negatively to disinhibition.

The Herman-Polivy questionnaire does not operate as a determinant of successful weight maintenance. Since the first and representative question of the Herman-Polivy questionnaire is 'How often are you dieting?' and since other questions deal with weight fluctuations in the past, it is clear that the Herman-Polivy restraint questionnaire identifies a dieting person, irrespective of the actual situation or behaviour.

From this study we may conclude, although the number of subjects that participated in this substudy of the weight cycling project was relatively small, that an increase in cognitive restraint, from before to during the diet, is one of the determinants of weight maintenance in subjects who do not drop out half way. Secondly, a positive correlation between cognitive restraint and disinhibition contributes to a more flexible attitude towards food consumption, which also turns out to be relatively more successful. From this observation during a dieting period, prediction of weight maintenance thereafter seems to be possible.

References

1 Kuczmarski RJ, Flegal KM, Campbell SM, Johnson CL. Increasing prevalence of overweight among US adults. The National Health and Nutrition Examination Surveys, 1960 to 1991. *JAMA* 1994; **272**: 205–211.
2 Mikkelsen KL, Heitmann BL, Sorensen TIA. Secular changes in mean body mass index and in the prevalence of obesity. Three Danish population studies of 31 000 subjects. *Int J Obes* 1995; **19**: 527 (Abstr).
3 Chan JM, Rimm EB, Colditz GA, Stampfer MJ, Willet WC. Obesity, fat distribution, and weight gain as risk factors for clinical diabetes in men. *Diabetes Care* 1994; **17**: 961–969.
4 Manson JE, Colditz GA, Stampfer MJ, Willet WC, Rossner B, Monson RR, Speizer FE, Hennekens CH. A prospective study of obesity and risk of coronary heart disease in women. *N Engl J Med* 1990; **322**: 882–889.
5 Pi-Sunyer FX. Health implications of obesity. *Am J Clin Nutr* 1991; **49**: 1115–1123.
6 Willet WC, Manson JE, Strampfer MJ, Colditz GA, Rosner B, Speizer FE, Hennekens CH. Weight, weight change, and coronary heart disease in women. *JAMA* 1995; **273**: 461–465.
7 van Dale D, Saris WHM, ten Hoor F. Weight maintenance and resting metabolic rate 18–40 months after a diet/exercise treatment. *Int J Obes* 1990; **14**: 347–359.
8 Garner DM, Wooley SC. Confronting the failure of behavioral and dietary treatments for obesity. *Clin Psychol Rev* 1991; **11**: 729–780.
9 Williamson DF, Serdula MK, Anda RF, Levy A, Byers T. Weight loss attempts in adults: goals, duration and rate of weight loss. *Am J Public Health* 1992; **82**: 1251–1257.
10 Blackburn GL, Wilson GT, Kanders BS, Stein LJ, Lavin PT, Adler J, Brownell KD. Weight cycling: the experience of human dieters. *Am J Clin Nutr* 1989; **49**: 1105–1109.
11 Brownell KD, Greenwood MRC, Stellar E, Shrager EE. The effects of repeated cycles of weight loss and regain in rats. *Physiol Behav* 1986; **38**: 459–464.
12 Blair SN, Shaten J, Brownell K, Collins G, Lissner L. Body weight change, all-cause mortality, and cause-specific mortality in the Multiple Risk Factor Intervention Trial. *Ann Intern Med* 1993; **119**: 749–757.
13 Hamm P, Shekelle RB, Stamler, J. Large fluctuations in body weight during young adulthood and twenty-five year risk of coronary death in men. *Am J Epidemiol* 1989; **129**: 312–318.
14 Lissner L, Bengtsson C, Lapidus L, Larson B, Bengtsson B, Brownell KD. Body weight variability and mortality in the Gothenburg Prospective Studies on men and women. In: Bjorntop P, Rossner S (eds). *Obesity in Europe 88: Proceedings of the First European Congress on Obesity.* Libbey: London, 1989; pp 55–60.
15 National Task Force on the Prevention and Treatment of Obesity. Weight cycling. *JAMA* 1994; **272**: 1196–1202.
16 Wing RR. Weight cycling in humans: a review of the literature. *Ann Behav Med* 1992; **14**: 113–119.
17 Wing RR. Weight cycling: the public concern and the scientific data (editorial). *Obes Res* 1993; **1**: 390–391.
18 Zelitch Yanovski S. Weight cycling (editorial). *JAMA* 1995; **273**: 999.
19 Astrup A, Beumann B, Gluud C, Bennet P, Tjur T, Christensen NJ. Prognostic markers for diet-induced weight loss in obese women. *Int J Obes* 1995; **19**: 275–278.
20 Colberg SR, Simoneau J, Thaete FL, Kelley DE. Skeletal muscle utilization of free fatty acids in women with visceral obesity. *J Clin Invest* 1995; **95**: 1846–1853.
21 Keim NL, Barbieri TF, Van Loan M. Physiological and biochemical variables associated with body fat loss in overweight women. *Int J Obes* 1991; **15**: 283–293.
22 Kempen KPG, Saris WHM, Senden JMG, Menheere PPCA, Blaak EE, van Baak MA. Effects of energy restriction on acute adrenoceptor and metabolic responses to exercise in obese subjects. *Am J Physiol* 1994; **267**: E694–E701.
23 Kreitzman SN, Coxon AY, Johnson PG, Ryde SJS. Dependence of weight loss during very-low calorie diets on total energy expenditure rather than on resting metabolic rate, which is associated with fat free mass. *Am J Clin Nutr* 1992; **56**: 258S–261S.
24 Prentice AM, Goldberg GR, Jebb SA, Black AE, Murgatroyd PR. Physiological responses to slimming. *Proc Nutr Soc* 1991; **50**: 441–458.
25 Webster JD, Garrow JS. Weight loss in 108 obese women on a diet supplying 800 kcal/d for 21 d. *Am J Clin Nutr* 1989; **50**: 41–45.
26 Kempen KPG, Saris WHM, Blaak EE, Stegen JCHC, Kester ADM. Predictors of fat loss during very-low calorie diet in obese females. In: Kempen KPG. *Metabolic effects of weight cycling in obesity.* PhD Thesis, Universitaire Pers Maastricht, 1996; pp 59–68.
27 Astrup A, Buemann B, Gluud C, Bennet P, Tjur T, Christensen N. Prognostic markers for diet-induced weight loss in obese women. *Int J Obes* 1995; **19**: 275–278.
28 Herman CP and Polivy J. Restrained eating. In: Stunkard A (ed). *Obesity*, WB Saunders: Philadelphia, 1980, pp 208–224.
29 Stunkard AJ, Messick S. The three factor eating questionnaire to measure dietary restraint, disinhibition, and hunger. *J Psychosom Res* 1985; **29**: 71–83.
30 Westerterp-Plantenga MS, Wouters L, ten Hoor F. Restrained eating, obesity, and cumulative food intake curves during four course meals. *Appetite* 1991; **16**: 149–158.

31 Heatherton TF, Herman CP, Polivy J, King GA, McGree ST. The (mis)measurement of restraint; an analysis of conceptual and psychometric issues. *Abn Psych* 1988; 97 **1**: 19–28.
32 Westerterp-Plantenga MS, Van den Heuvel E, Wouters L, Ten Hoor, F. Dietary restraint and disinhibition in overweight women during a four month dieting period. In: *Psychobiology of food intake in humans.* PhD Thesis, Maastricht University, 1991; 119–135.
33 Herman CP, Mack D. Restrained and unrestrained eating. *J Personality* 1975; **43**: 647–660.
34 Westerterp-Plantenga MS, Westerterp KR, Nicolson NA, Mordant A, Schoffelen PFM, ten Hoor F. The shape of the cumulative food intake curve in humans, during basic and manipulated meals. *Physiol Behav* 1990; 47 **3**: 569–576.
35 Tuschl RJ, Platte P, Laessle RG, Stichler W, Pirke KM. Energy expenditure and everyday eating behavior in healthy young women. *Am J Clin Nutr* 1990; **52**: 81–86.
36 Kempen KPG, Blaak EE, van Baak MA, Saris WHM. Weight cycling is associated with blunting of the sympathetically mediated thermogenesis in obesity. In: Kempen KPG: *Metabolic effects of weight cycling in obesity.* PhD Thesis, Universitaire Pers Maastricht, 1996, pp 69–85.
37 Westenhoefer J, Broeckmann P, Munch A, Pudel V. Cognitive control of eating behaviour and the disinhibition effect. *Appetite*, 1994; **23**: 27–41.
38 Westenhoefer J. Dietary restraint and disinhibition: is restraint a homogeneous construct? *Appetite*, 1991; **16**: 45–55.