

Effects of weight loss on single meal eating behaviour in obese subjects

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ABSTRACT: In 22 obese patients the eating pattern during a single meal as evaluated by the universal eating monitor VIKTOR was assessed after one year of treatment, initially with VLCD (Nutrilett) followed by combined long term diet, exercise and behavioural modification, underscoring the importance of appropriate meal habits. A mean weight loss from 117 to 101 kg was achieved. Before treatment a decelerated eating curve was found; after treatment this curve changed significantly towards a flatter and more linear shape.

Keywords: eating behaviour; obesity; universal eating monitor; VLCD

Introduction

A standard weight loss program which results in any sustained weight loss is generally a combination of dietary recommendations, increased physical activity and behavioural modification. Programs can be designed in numerous ways, but it seems clear that it is important to envisage obesity as a chronic condition, requiring treatment in some form over a long period of time. To some of our basic long term treatment programs¹ we have incorporated an early time period using very low calorie diets (VLCD). Although there is agreement that VLCDs result in immediate and dramatic weight loss, there is still a concern that the results over years will not be significantly improved unless the VLCD period is considered an integrated part of a long term treatment approach.²

We have used our version of the universal eating monitor 'VIKTOR' to study in detail the characteristics of the eating behaviour during a single meal of a homogenous hot lunch dish. VIKTOR measures the amount of food consumed, the duration of the meal, the eating rate and additionally the shape of the eating curve over time. Generally a decelerated eating curve is found, which means that the rate of food consumption during the first part of the test meal is higher than during the later part of the meal. By some researchers this has been referred to as 'the biological satiation curve'.³ In some observational studies^{4,5} and in studies with the liquid food dispenser^{3,6} it has been demonstrated that obese subjects do not slow down their eating rates towards the end of the meal to the same extent as normal weight individuals, but these findings have not always been supported by objective laboratory methods, such as the universal eating monitor.^{7-10,12}

We have previously demonstrated that single meal

total food intake as studied by VIKTOR may be significantly reduced after changes of the preceding meal towards a higher protein content.¹¹ The present short report demonstrates that weight loss, including initial VLCD treatment, may affect the shape of the eating curves as measured by VIKTOR.

Patients and methods

Twenty-two patients (15 women) formed a subsample of a patient group, who completed a conventional combined weight losing program. The mean age of the 22 patients was 49 ± 9 years (SD) and the mean BMI before treatment 34.3 ± 3.7 kg/m². From 81 patients entering the clinical trial the 22 were taken at random immediately before the onset of the VLCD treatment programme and invited to eat two lunch meals on the VIKTOR before and after one year of treatment. The patients were given an initial VLCD treatment for the first 8 weeks of the program containing 430 kcal/day (Nutrilett, Nycomed, Oslo) to be followed by a balanced hypocaloric diet containing about 1600 kcal/day for the following year. The diet consisted of common Swedish food items low in fat and concentrated more on food types, appropriate portion sizes and principle cooking methods than on detailed recipes. General physical activity was encouraged but did not constitute a formal part of the program. The patients were seen during the VLCD period once a week and urine samples to check compliance by measuring urinary ketone levels were collected on each occasion. After a transition phase the patients then shifted over from VLCD to the diet and were seen throughout the year about every second week. Part of the behaviour modification concentrated on techniques to consume each meal. The following aspects were underscored: Patients were instructed to eat slowly and let each main meal last for at least 20 minutes, to eat regularly and at the same place at home, to remove other food cues from their immediate sur-

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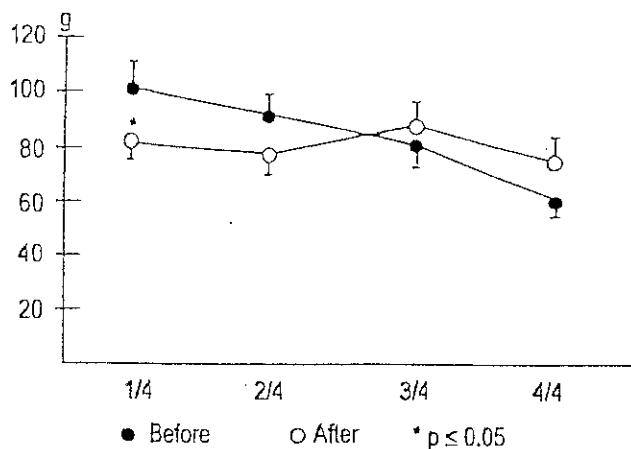


Figure 1 Food intake (g) during quartile 1-4, derived from the eating monitor VIKTOR in 22 patients before and after weight loss from 117 to 101 kg. SEM shown; * $p < 0.05$.

rounding, to put down knife and fork after each bite and to chew each bite at least 20 times. These are standard recommendations used in numerous previous treatment programs, and systematically applied.

We have developed a universal eating monitor, based on the concept initially described by Kissileff.¹² The VIKTOR technique has been described in detail elsewhere as regards patient information, eating situation, timing, etc.^{10,11} In summary, in an eating laboratory an excess portion of a typical homogenous hot lunch dish (Swedish hash, 150 kcal/100 g, 42 energy% fat, 1 g dietary fibre/100 g) was served on a plate, which was placed on a scale, built into a table. The meal was served at approximately each individual lunch time. The subjects were instructed to eat as much as they liked.

A computer identified every second the weight signal from the scale and transformed the data into an eating curve. Data on food consumption (g), duration (min), eating rate (g/min) during the entire meal and during each quartile were calculated, as well as Im, an indicator of the shape of the eating curve.⁷ Im was calculated as the food intake during the first half of the meal minus the intake during the second half of the meal divided by the total food intake. A value exceeding 0.10 suggests a decelerated eating pattern, i.e. more than 55% of the solid meal was consumed during the first half of the test meal. In addition, questions concerning the subjective motivation to eat (desire to eat, hunger, fullness and prospective consumption) and the pleasantness of the food, as measured by horizontal visual analogue scales were filled out immediately before and after the meal. The VIKTOR procedure was repeated in an identical way after one year of treatment.

Before treatment the patients filled out the Three-Factor Eating Questionnaire (TFEQ) measuring cognitive restraint, disinhibition and general hunger.¹³

Statistical analysis was performed by paired *t*-tests. In all situations two-sided tests with a significance level of 5% were used. All patients gave their informed consent to participate in the study, which had been approved by the Karolinska Hospital Ethics Committee.

Results

After one year, the mean body weight of the 22 patients had dropped from 117 ± 25 to a stable weight 101 ± 17 kg ($p < 0.0001$), the mean weight \pm SD being identical 2 weeks prior to the test day. The amount of the test meal consumed did not change significantly from 336 ± 122 to 323 ± 126 g and the duration of the meal was not affected by treatment, from 9.0 ± 3.5 to 8.3 ± 2.7 min. Thus the overall change of the eating rate was not significantly altered, from 36 ± 11 to 39 ± 11 g/min. However, the shape of the eating curve was altered after weight loss. This could be described in several ways: The mean Im value fell from 0.15 ± 0.12 to 0.01 ± 0.16 ($p = 0.0004$), the absolute food consumption during the first quartile fell from 102 ± 42 to 82 ± 31 g ($p = 0.019$) and the rate of food consumption during the fourth vs the first quartile of the meal increased from 0.68 ± 0.44 g/min to 0.97 ± 0.44 g/min ($p = 0.036$). Food intake for each quartile before and after treatment are shown in Figure 1. For the statistically significant findings the differences \pm SD were for the first quartile 20.1 ± 8.0 , for the ratio between quartiles 1/4 0.29 ± 0.13 and for Im 0.14 ± 0.03 .

The visual analogue scale ratings of desire to eat, hunger, fullness and prospective consumption were not significantly affected by the weight loss, and the meal was equally well liked on both study occasions.

In the analysis of the TFEQ before treatment, the mean score for restrained eating was 9.3 ± 5.2 , for disinhibition 11.2 ± 3.6 and for hunger 6.0 ± 3.0 . With a cut-off point for restrained eating of 9.0,⁷ 29% of the males and 70% of the females were found to be restrained eaters already before treatment.

Discussion

Before treatment the mean Im-value of 0.15 ± 0.12 in the group suggests a decelerated eating pattern.³ In a parallel methodological study of 19 + 19 untreated obese men and women we found a mean Im value of 0.12 ± 0.11 for men and 0.09 ± 0.21 for women under similar eating conditions.¹⁰ Furthermore, the food consumption and eating rates were similar.

No difference in the shape of the eating curves after single test meals on universal eating monitors were found in studies where normal weight and obese subjects were compared.^{7-10,12} After a 14% weight loss we found a significant flattening of the eating curve towards a more linear shape. This flattening was identified by different (although certainly not independent) ways to calculate the shape of the curve, which suggests that this was not a chance finding. Other changes in the eating curve in our study could theoretically be envisaged, such as a reduction in food intake but still a decelerated eating curve, but no such trend was observed.

In earlier work, a decelerated eating pattern has been suggested to reflect internal satiation signals,³ although

this hypothesis has been disputed.¹⁴ The VLCD program during the first period of the trial does not allow a normal food intake behaviour, but this period was far behind in time. It is possible that the behavioural components of the program and the repeated instruction by the study nurse, the dietician and the physician have resulted in a change in the shape of the eating curve.

Already before treatment a restrained eating pattern was found in most women. The data from the TFEQ¹³ are similar to results obtained in our previous study of obese men and women.¹⁰ Björvell demonstrated that restraint in obese individuals increases with weight loss.¹⁵ The patients reported practically identical feelings after the test meals before and after weight loss as concerned the desire to eat, hunger, fullness and prospective consumption and so it seems less likely that differences in motivation to eat explain the altered shape of the eating curve.

We conclude that marked changes of the eating curve may occur in spite of (or because of) successful and sustained weight loss. From a methodological point of view this means that the eating curve obtained by the VIKTOR technique can be perturbed not only as regards food intake and meal duration but also with respect to the shape of the eating curve at similar total intakes during similar time of consumption. Further studies will be necessary to elucidate the mechanisms causing these changes in the curve configuration.

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Weight reduction in obese patients with rheumatoid arthritis, with preservation of body cell mass and improvement of physical fitness

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ABSTRACT. Objective. To reduce body weight in obese patients with rheumatoid arthritis (RA) without loss of body cell mass (BCM) and without impairment of physical performance.

Methods. Nineteen overweight RA patients were studied before, during, and after a 12-week weight reducing regime consisting of reduced dietary energy intake, supplemented with a high-protein-low-energy powder preparation, and moderate physical training. Body composition was measured by a four compartment method, which by combining determinations of total body water and total body potassium allows a distinction between the two variable components of fat free mass (FFM): BCM and extracellular water (ECW). Physical fitness was measured by a bicycle exercise test.

Results. Mean weight loss during the study was 4.5 kg. The patients lost 9% of their initial fat mass, 3% of initial BCM and 5% of initial ECW. Physical fitness was slightly, but significantly, improved.

Conclusion. The regime described was successful in achieving a significant weight loss with minimal loss of BCM and maintenance of physical fitness.

Key words: rheumatoid arthritis, weight reduction, body cell mass, fat free mass, fat mass, physical fitness.

Introduction

Obesity in patients with rheumatoid arthritis (RA) may impair joint function. However, a weight reducing regime may aggravate the clinical condition due to loss of body cell mass (BCM), in particular muscle mass. Muscle mass is low in RA patients and this is associated with decreased muscle strength (1-3). Therefore, a weight reducing regime in RA patients should aim at reducing fat mass (FM) while preserving BCM and muscle function. In healthy obese individuals this can be achieved by a high protein intake, which counteracts the loss of body protein during

energy restriction (4), and exercise which reduces the loss of non-adipose tissue (i.e. fat free mass = FFM) during weight loss (5). This could also be the case in patients with RA but due to the inflammatory, catabolic nature of the disease the efficiency of these measures cannot be known with certainty *a priori*.

In healthy obese individuals it is customary to study the composition of weight loss divided into FM and FFM. In general, weight loss consists of 75% FM and 25% FFM (4). FFM consists of two major components, however: BCM and extracellular water (ECW). Patients with RA may have an elevated ECW due to the inflammatory disease and/or intake of prednisolone or non-steroidal anti-inflammatory drugs, and at the same time they may have a reduced BCM. In addition, the BCM of patients with RA could be abnormally sensitive to an inadequate dietary intake. Hence, the loss of a 'normal' amount of FFM could represent an exaggerated loss of BCM and it is therefore

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necessary to measure BCM specifically in these patients, as can be done by the 'four compartment' method (6). In addition, it is also warranted to ascertain that the preservation of BCM is accompanied by the maintenance of muscle function and that weight reduction occurs without a deterioration of the clinical status. In the present study, we investigated whether these goals could be achieved by combining a high-protein-low-energy diet with an exercise programme.

Patients and methods

Patients. 20 patients (3 males and 17 females) with RA who wished to lose weight were selected from the out-patient clinics of several rheumatological departments in Copenhagen. All patients fulfilled the criteria for RA of the American Rheumatism Association (7). All were more than 10% overweight according to Lindberg *et al.* (8). Patients with heart, lung, or kidney disease were excluded from the study. Patients continued their medication unchanged during the study. Further details are given in Table I. All patients gave their written informed consent, and the study was accepted by the local ethical committee.

Diet. The weight reducing treatment lasted for 12 weeks. The study was initiated by a one week dietary recall. The patients were then instructed to reduce their energy intake by 30%, primarily by reducing dietary fat. To increase protein intake, a high-protein-low-energy, vitamin and mineral supplemented powder (Nurilett, Nycomed Pharma, Norway) was employed (9) in an amount providing 62 g of high quality protein per day. After the first week, all patients had a brief second interview to solve individual adherence problems.

Compliance was estimated by one week dietary recalls after 6 weeks and at the end of the study. Reported protein intake was

Table I. Characteristics of the patients with rheumatoid arthritis. Values are given as the median (range).

Age, years	55	(34 - 71)
Duration of RA, years	8	(1 - 34)
Functional class of RA ¹	1	(1 - 11)
Dose of prednisolone, mg/day ²	6.25	(2.5 - 12.5)
Duration of prednisolone therapy (yrs)	3	(1 - 37)
Erythrocyte sedimentation rate (mm) ³	32	(2 - 104)

¹According to Steinbrocker *et al.* (JAMA 1999; 140: 659 - 62): Functional class I: Capable of all activities. Functional class II: Moderate restriction (adequate for normal activities despite handicap of discomfort or limited motion at one or more joints).

²Two patients were taking prednisolone only, 8 were taking both prednisolone and NSAIDs, 5 were taking NSAIDs only, and 4 were not taking any of these drugs.

³Normal range: 2 - 20 mm.

compared to protein loss estimated from 24 h urea excretion (10). Reported energy intake was related to total energy expenditure as calculated by the factorial method (10). After completion of the 12-week study, the patients were encouraged to continue an energy reduced diet with a low fat content, and to volunteer for a final dietary interview and weight recording one year later. Fourteen of the 19 patients who completed the study presented themselves at this final examination.

Physical fitness and exercise programme. Before the weight reducing regime was introduced, each patient's physical fitness (aerobic capacity) was measured by a bicycle exercise test, carried out at 50% and 65% of the estimated $\dot{V}O_{2max}$ (11). The heart rate and subjective 'rating of perceived exertion' were registered at the end of each work-load period (12). The test was repeated after the 12-week weight reducing regime, employing the same absolute work-load for each patient.

A physical training programme was adjusted to the needs of each patient and the patients were instructed to perform the programme at home 3 times a week. The programme was composed of dynamic strength and conditioning exercises for approximately 20 min, initiated by 10 min of warming-up, and terminated by 5 min of stretching exercises. On non-exercise days the patients were encouraged to take a walk for 30 min. The instructions were given before the study and were repeated at the follow-ups by the same physiotherapist 1 and 6 weeks into the study.

Body composition. Height was measured to the nearest 0.5 cm with subjects standing without shoes. Body weight was measured to the nearest 0.1 kg with the subjects lightly dressed. Total body water (TBW) was determined by isotope dilution (13) and total body potassium (TBK) was determined by measuring ⁴⁰K (14). These measurements were used to calculate the four body compartments (6), which consist of the FFM, ECW, FM, and 'fat-free extracellular solids' (FFECS). FFECS represents an estimate of the bone and other solid components of the FFM, calculated from the height, and is not believed to change during weight reduction. BCM is calculated from the TBK, and ECW is calculated by subtracting the intracellular water associated with BCM from the TBW. Finally, FM is calculated by subtracting the sum of FFECS, BCM and ECW from the total body weight.

Clinical status. Clinical status was evaluated by the patient on a visual analogue scale (VAS) from 0 to 100 mm. The patient scored general symptoms (tiredness, decreased appetite) and joint pain. Clinical status was also evaluated by the physician who recorded the number of tender joints at physical examination and recorded the patient's report of the duration of morning stiffness.

Statistical analysis. Wilcoxon's paired test was used to evaluate the statistical significance of the data.

Results

Patients. Nineteen of the 20 patients completed the study. One patient withdrew from the trial after one week because of increasingly tender joints which precluded the exercise programme. Two of the 19 patients were hospi-

Table II. Dietary intake and compliance. Values are given as the mean \pm SEM.

	Pre-study interview	Midway interview	Final interview	P-values versus pre-study interview	
Reported energy intake (MJ/d)	8.0 \pm 0.6	6.3 \pm 0.4 ¹	6.8 \pm 0.5 ²	0.004 ¹	0.038 ²
Calculated energy expenditure (MJ/d)	9.4 \pm 0.5	9.9 \pm 0.7	9.6 \pm 0.7		
Reported protein intake (g/d)	70 \pm 5	113 \pm 4 ³	112 \pm 5 ⁴	0.0001 ³	0.0005 ⁴
Protein loss (g/d [*])	84 \pm 4	113 \pm 7 ⁵	101 \pm 6 ⁶	0.0005 ⁵	0.0065 ⁶

* Calculated from 24 h urea excretion (see text). Superscripts refer to p-values in the same row.

alized during the trial, one because of increased disease activity and anemia and one because of urolithiasis. Both were hospitalized for one week during which the diet was continued, but no exercise was done.

Dietary intake. Reported energy intake at the pre-study interview was 85% of the calculated energy expenditure (Table II). The patients' reported energy intake decreased by 21% and 14% at the two follow-up interviews after 6 and 12 weeks, respectively. Reported protein intake was 83% of the protein loss at the pre-study interview and was close to protein loss at the two follow-up interviews. Reported fat intake was 41% of the total energy intake initially, and at the end of the study this was reduced to 25% (data not shown).

The 14 patients re-examined after one year reported their daily energy intake to be 6.9 ± 0.4 MJ, with fat accounting for 34% of the total.

Body weight and body components. The initial body composition and changes during weight loss are shown in Table III. Initial body weight was $133 \pm 3\%$ of the reference weight (8) and the mean weight loss during the 12 weeks of treatment (Table III) corresponded to 22% of the overweight. Loss of FM constituted 62% of the total weight loss and loss of FFM constituted 38% (ECW 25%, BCM 13%). Loss of BCM was about 3% of the initial BCM.

There were no significant differences in initial body weight, body composition, or in the loss of body components, between the 10 patients who took prednisolone and the 9 patients who did not.

The 14 patients who participated in the final investigation after one year had a similar mean weight loss during the 12 week study and one year later their body weight had remained stable (body weight had increased by 0.32 ± 1.19 kg).

Exercise. Most patients reportedly carried out their exercise programme as required. Aerobic capacity increased during the study (at 65% of V_{O_2} max: initial pulse rate 140

± 3 /min, final pulse rate 134 ± 4 /min, $p < 0.05$). There was no change in the subjective 'rating of perceived exertion'.

Clinical status. There was no change in clinical status during the study period, either as scored by the patient for general symptoms, joint pain or duration of morning stiffness, or as scored by the physician for the number of tender joints, or as measured by the erythrocyte sedimentation rate (data not shown).

Discussion

At the initial interview, reported protein intake was less than protein loss (Table II) and reported energy intake was lower than the calculated energy expenditure. This suggests underreporting of dietary intake which is common among obese individuals (15). At the midway and final interviews, the agreement between reported protein intake and measured protein loss indicated a satisfactory compliance to the high protein diet.

Table III. Initial body composition and reduction during weight loss. Values are given as the mean \pm SEM.

	Initial value	Reduction	P-values vs. no change
Height (cm)	165 \pm 2		
Body weight (kg)	82.5 \pm 2.9	4.47 \pm 0.51	0.0001
FFES (kg)	7.6 \pm 0.2		
FM (kg)	32.4 \pm 1.6	2.74 \pm 0.84	0.011
FFM (kg)	50.1 \pm 2.1	1.73 \pm 0.61	0.019
ECW (l)	20.8 \pm 0.8	1.13 \pm 0.62	
BCM (kg)	21.8 \pm 1.4	0.59 \pm 0.44	

FFES: Fat-free extracellular solids; FM: Fat mass; FFM: Fat free mass; ECW: Extracellular water; BCM: Body cell mass (see text for further explanation).

To the best of our knowledge body composition analysis including ECW and BCM has never been performed in RA patients prior to this study. When compared to a group of 41 healthy, equally obese, women (personal communication from B.L. Heitmann in collaboration with the Copenhagen County Centre of Preventive Medicine, Medical Dept. C, Glostrup University Hospital, Denmark) our patients had a slightly higher ECW (20.8 ± 0.8 l versus 19.2 ± 0.6 l) and a slightly lower BCM (21.8 ± 1.4 kg versus 22.4 ± 0.5 kg). However, these differences were not statistically significant and the decreased muscle mass previously reported in RA patients (1, 2) was not reflected in a significantly decreased BCM in our patients, perhaps due to the moderate severity of the disease (Table I).

No published studies of healthy obese individuals are directly comparable to the present study, which combined a high protein intake with an exercise programme. In our patients the weight loss consisted of 62% FM and 38% FFM. The latter figure is higher than the 25% usually found during weight reduction (4). However, measurement of the BCM and ECW indicated that the loss of FFM in our patients was mainly due to loss of ECW. In addition, the data on protein intake and protein loss (Table II) indicated that body protein was preserved during weight loss. In healthy obese individuals, a high-protein-low-energy diet preserves BCM to the same degree (also measured by ^{40}K) during the same amount of weight loss (16) and also maintains body protein (17).

In an earlier publication from this study (18) we compared the changes in FM and FFM, as measured by the 'four compartment' method, to 7 other common methods for the estimation of FM and FFM. With these other methods, loss of FFM accounted for 23-51% of the total weight loss and therefore no method devised for the estimation of FFM would be able to document the preservation of BCM and body protein in these patients.

Preservation of the BCM was probably also facilitated by the exercise programme, since FFM is known to be preserved by exercise during weight reduction (5). The decrease in heart rate during exercise at the end of the study indicated an increase in aerobic capacity. This was probably a result of the exercise programme and demonstrates that muscle function was preserved during weight loss.

Clinical status, as evaluated by the patients and physicians, was not affected by the weight loss, suggesting that the regime employed in our study was without adverse effects. In fact, weight loss could be anticipated to improve the clinical status in obese RA patients by improving joint function, but to demonstrate such an effect a larger weight loss and/or a more severe degree of initial overweight is probably required.

At the one year follow-up of 14 of 19 patients, the weight loss had persisted, which is often not the case in

healthy obese individuals (17). This, and the dietary interview, suggest that the patients had permanently changed their dietary habits and were highly motivated for the weight loss.

The findings of the present study are in accordance with results from the literature on healthy obese subjects. However, RA is an inflammatory catabolic disease, often treated with prednisolone which further aggravates the catabolic state, and it was an open question whether the regime described in the present paper could preserve BCM and muscle function in patients with RA.

In conclusion, a high-protein-low-energy diet combined with exercise is capable of promoting a significant weight loss in patients with RA while at the same time preserving BCM and muscle function, and is without adverse clinical effects.

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