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ORIGINAL CONTRIBUTION

Successful weight loss and maintenance in everyday clinical practice with an individually tailored change of eating habits on the basis of food energy density

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Abstract
Background Weight change was analyzed in a cohort of obese patients whose eating habits were changed individually mainly on the basis of food energy density (ED) to evaluate the feasibility of this concept for a larger controlled trial.
Method Five hundred and thirteen outpatients were treated between January 2003 and December 2006. Dietary counseling was based on a pretreatment food diary. In January 2008, a follow-up (FU) was made. For pre- and post-change eating habits, 5184 dietary protocols of 189 patients were analyzed.
Results During 10.5 months of treatment, patients lost weight from an initial BMI of 38.8 ± 8.5 by −0.195 kg/m^2 per month; 36% had weight loss >5%, 44% lost 0–4.9% and 20% had weight gain. At follow-up, 413 patients (80.5%) were reached of whom 80 were still in treatment while 333 were considered as self-treatment (ST) group. The ST group had further weight loss by −0.053 kg/m^2 per month over 16.8 months (40% weight loss, 46% maintenance and 14% weight gain), and 164 patients with type-2-diabetes had greater weight loss compared to those without diabetes during ST (Δ-BMI-0.166 vs. −0.028 points/month; $p < 0.0001$). Energy intake (EI) was reduced by lower ED, beverages and number of meals. Average carbohydrate, fat and protein intake was reduced by 28, 42, and 7%, respectively.
Conclusion In a unselected cohort of substantially obese patients, the individual change of eating habits based primarily on food ED in conjunction with beverage intake and meal frequency weight loss continued beyond the supported treatment phase indicating a good patient adherence. We consider these data as an encouraging pilot study that certainly requires confirmation under controlled conditions.

Keywords Obesity treatment · Weight maintenance · Self-treatment · Dietary counseling · Type 2 diabetes · Macronutrients · Treatment cost

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Introduction

Worldwide obesity is rapidly increasing, and it favors the development of numerous serious and life-threatening diseases [1]. On the other hand, weight loss has been shown to reduce obesity-related comorbidities and also mortality [2–8]. Therefore, it is extremely important to increase the effort in long-term weight management. As yet, substantial long-term maintenance of weight loss in the majority of study subjects is accomplished only by surgical interventions [7, 8] while non-surgical treatment modalities have the problem of progressive weight regain either already during treatment [9, 10] or after its termination [11–13].

For successful weight loss, various concepts of dietary intervention such as low fat or low carbohydrate (carb) have been advocated [14, 15]. Furthermore, an increase of the protein/carbohydrate ratio in conjunction with a low-fat regimen has shown favorable effects [16–18]. The direct comparison of various dietary regimens over a 2-year period did not show major differences with regard to

weight loss [9, 19–21] but it should be kept in mind that these studies had no further follow-up period. Apart from restrictions of energy intake and modifications of macronutrient ratios behavioral interventions have been shown to be important for successful weight loss [22, 23].

In recent years, several studies have demonstrated the important role of food energy density (ED) for acute energy intake. ED refers to the amount of energy in a given weight of food (kJ/g). ED is determined predominantly by the fat and/or water content of food. In man, acute activation of satiety signals is largely due to filling and distention of the stomach while the energy content is of minor importance and accordingly, ED reflects best the relationship between the satiating capacity of a food item and its contribution to energy intake. Thus, food items with higher ED favor a greater energy intake at an identical degree of satiation which has been demonstrated in several feeding experiments [24–31]. Epidemiological studies have presented evidence for a good correlation between food ED and overall energy intake in large populations [32–34]. Moreover, the efficacy of food ED in obesity treatment is supported by several studies [35–37].

Previously, we recommended patients a low-fat diet for weight loss. The analysis of eating habits, however, has shown that those subjects who experienced a transient weight reduction followed by a rapid regain overcompensated fat-restriction by greater carbohydrate intake [38]. Therefore, we decided to shift the focus in dietary counseling from the macronutrient ratio to the energy content of food items. Since 2003, the current concept of obesity treatment has been established in our outpatient clinic to modify food intake on an individual basis of the patient's eating habits using ED of all generally available food items to obtain a sufficient reduction of energy intake for weight loss. A major focus of this treatment concept is to have a large carry-over effect from the treatment phase to the ensuing period of further unsupported self-treatment which is definitely required for most obese subjects to at least maintain or even augment weight loss. This concept, up to our knowledge, has not been examined so far.

Here, we report the analysis of this treatment concept over a 4-year period to decide whether this pilot project deserves a future follow-up under controlled conditions.

Methods

All patients who contacted the outpatient clinic of the department of nutritional medicine between January 2003 and December 2006 with the intention to lose weight were included in the analyzed cohort. This intervention is considered as a pilot study with no control group to evaluate the feasibility of this concept for a larger controlled trial. Excluded were mentally disabled subjects, patients with age <18 years, body mass index (BMI) <25 kg/m^2 or type 1 diabetes mellitus, respectively. Patients can refer themselves or on initiative of their physician, respectively. The duration of treatment is principally unlimited and treatment costs are covered by the social insurance system. For follow-up data (FU), patients were contacted in January 2008 by phone, mail or the family physician to report their actual weight and they were asked whether they had participated in other weight loss programs.

Dietary intervention

The aim of our treatment concept was to change eating habits toward hypocaloric nutrition in conjunction with adequate satiety and preservation of as many of the most favored dishes and food items as possible with the expectation to improve long-term adherence to an individually tailored portfolio of food items. The basis for dietary counseling was a food diary of at least 10 days or more to gain insight into the "old" eating habits. The protocols should contain in as detailed a manner as possible every item they either eat or drink, the time they consumed it, the amount they ate and how the food was prepared. To improve motivation, patients were told that an accurate recording improves individual counseling, and the most preferred food items of their usual diet will remain unchanged as long as possible. Patients were handed out a booklet with examples of characteristic portion sizes in case of eating out.

During the first counseling session, suggestions were made to substitute low ED for high ED food items. Counseling was provided by a dietitian (M.H.) and two physicians (J.E.; V.S.). As support patients had a booklet with the ED of approximately 1500 food items divided into 37 food groups [39]. Within each group, the items are listed in an ascending order of their ED. Low ED food ($\leq$1.5 kcal/g) is marked green, medium ED (1.6–2.4 kcal/g) yellow, high ED food ($\geq$2.5 kcal/g) red. The limit of 1.5 kcal/g for low ED food is based on the average quantity of daily food intake of 1,100 g assessed by the analysis of 2800 dietary records of obese subjects [39] and on the average basal metabolic rate of 1650 kcal/day determined by indirect calorimetry in 400 overweight and obese patients. Patients are told to select ad libitum amounts of low ED food to reach the portion size required to feel satiated. Medium and high ED food is thought to satisfy taste, sensory and cognitive cues. The differentiation between medium and high ED at 2.5 kcal/g is rather arbitrary with the intention to discriminate white bread and related products (high ED) from whole grain and mixed bread (medium ED). In Germany, bread consumption is responsible for approximately 20% of daily energy intake

of obese and also normal weight subjects [40, 41]. No daily limits were given for energy or macronutrient intake.

Snack consumption should be reduced as much as possible or adequate alternatives of lower ED should be preferred. Energy-containing beverages should be avoided since they have none or only little satiating effect [42] and an equicaloric reduction of solid food intake could lead to inadequate satiety.

Further recording of food was recommended to reinforce the learning process of becoming acquainted with new eating habits. The recommended interval between visits is 4 weeks. Patients were encouraged to increase their physical activity without any specific recommendation concerning duration and intensity.

Data analysis

At the first (baseline) and each subsequent visit, patient's weight was determined without shoes while wearing light clothing to the nearest 0.1 kg on a calibrated scale. Standing height at baseline for determination of BMI was measured. Furthermore, weight development during the preceding year was recorded. They were asked to determine their weight while wearing light clothing similar to the visits during treatment to avoid an artificial overestimation of weight loss and to provide another food diary of at least 10 days.

Calculations were made for weight at baseline, last visit of the treatment period (LV) and follow-up (FU). The treatment period was defined as time between baseline and LV, the follow-up period between baseline and FU. The self-treatment period (ST) is the time between LV and FU. Changes of weight are expressed as **Δ**-BMI per month of treatment.

Treatment costs were calculated on the basis of a dietitians gross salary (25.50€ per hour). For the first visit a duration of 45 min and for each following visit 20 min were considered for the calculation, respectively.

The dietary records were calculated with the program PRODI 4.5 Expert (Kluthe, Freiburg, Germany) as described in detail previously [40, 41, 43, 44]. The price of food was calculated by analyzing various shops and supermarkets as described previously [40]. Food and caloric beverages were analyzed separately, and energy density was calculated as the ratio between food energy (kJ) and weight (g) excluding caloric beverages. Non-caloric beverages were not considered. Macronutrients are expressed in absolute values (g) and as percent of total solid food energy intake.

All data are expressed as mean ± SD, and the 95% confidence interval is given in parentheses. For statistical analyses, *t* test for paired (comparison within groups) or unpaired (comparison between groups) data was employed, respectively. Where appropriate correction for multiple comparisons according to the procedure of Bonferoni-Holm was made. Values of $p < 0.05$ were considered significant. All data were analyzed by using SPSS (version 17.0).

Results

Baseline characteristics of all patients are shown in Table 1. All patients of visit 1 also showed up at least at visit 2. Two-thirds of the patients were women, 28% had no comorbidity, and they were free of any medication; 164 patients had type 2 diabetes mellitus (DM2), and 24% of those were treated with insulin at the start of dietary intervention. One-fifth of all patients took beta-blockers and 8% had psychiatric medication both known to increase body weight. The average reported weight change during the year preceding treatment was +3.5 kg. None of the patients had ever experienced unintentional weight loss.

Treatment phase

Mean treatment duration was 10.5 months associated with a significant weight loss from 112.8 ± 28.1 kg (110.4–115.3) to 107.8 ± 26.8 kg (105.4–110.1). The reduction of BMI per month of treatment was −0.195 points (Table 2). 20% of the patients had a small but significant weight gain while the majority had lost weight. The difference in weight loss between the >10% and the 5–9.9% group can be ascribed to the longer treatment period of the ≥ 10% group. Accordingly, weight loss per

Table 1 Baseline characteristics of all patients

Number of patients	513
Male/female (%)	174 (34)/339 (66)
Age (years)	50.1 ± 14.0 (48.9–51.3)
Patients with type 2 diabetes (%)	164 (32)
Age (years)	57.9 ± 10.2 (56.3–59.4)
Medications	
Antihypertensive therapy-no. (%)	171 (33.8)
ß-blocker-no. (%)	99 (19)
Lipid lowering therapy-no. (%)	67 (13.2)
Oral antidiabetic therapy-no. (%)	164 (32)
Insulin treatment-no. (%)	39 (8)
Antipsychotic and antidepressant therapy-no. (%)	42 (8)
Weight change during the preceding year (kg)	+3.5 ± 5.2 (3.04–3.94)
Δ-BMI per month pretreatment (kg/m^2)	0.100 ± 0.147 (0.086–0.112)

Mean ± SD (95% CI interval)

Table 2 Weight change and differential weight loss of the 513 patients until the end of treatment (LV) [mean ± SD (95% CI interval)]

	All patients	Weight loss groups at LV			
	$n = 515$	≥10%, $n = 93$	5–9.9%, $n = 92$	0–4.9%, $n = 228$	Weight gain, $n = 100$
BMI baseline (kg/m^2)	38.8 ± 8.5 (38.0–39.5)	40.8 ± 9.8 (38.8–42.8)	38.8 ± 8.8 (37.0–40.6)	38.2 ± 7.7[a] (37.2–39.2)	38.2 ± 8.7[a] (36.5–39.9)
Δ-BMI per month of treatment	−0.195 ± 0.396* (−0.229 to −0.160)	−0.435 ± 0.416* (−0.520 to −0.351)	−0.374 ± 0.370* (−0.449 to −0.298)	−0.176 ± 0.345*[a,b] (−0.221 to −0.132)	+0.152 ± 0.210*[a,b,c] (0.111 to −0.193)
Treatment period (months)	10.5 ± 11.6 (9.5–11.5)	23.2 ± 14.1 (20.3–26.0)	13.5 ± 11.1[a] (11.2–15.7)	6.4 ± 7.5[a,b] (5.5–7.4)	5.3 ± 6.5[a,b] (4.0–6.5)
Number of visits	6.0 ± 4.9 (5.6–6.4)	10.3 ± 7.0 (8.9–11.8)	7.1 ± 4.6[a] (6.1–8.0)	4.5 ± 3.4[a,b] (4.1–4.9)	4.5 ± 2.7[a,b] (3.9–5.0)

Significant difference of $p < 0.05$ or less: * versus basal; [a] versus ≥ 10%; [b] versus 5–9.9%; [c] versus 0–4.9%

month of treatment was similar. In the 0–4.9% group, weight loss was less and this can not be ascribed to the shorter treatment period (Table 2).

Since only few data exist for non-surgical treatment of extreme obesity, these patients were compared with those having BMI <40 kg/m^2. Weight loss was significantly greater in both groups with BMI ≥40 kg/m^2 (Table 3). Percentage of weight loss was not significantly different between groups (−5.2% BMI ≥ 45 kg/m^2, −4.8% BMI 40 kg/m^2, −4.0% <BMI 40 kg/m^2).

Follow-up

Four hundred and thirteen patients (80.5%) were reached at follow-up, the others could not be found. None had participated in other weight loss programs. All parameters of this group at the end of the treatment period (LV) were not significantly different from those of all 513 patients. Weight change is shown in Table 4. Similarly, weight loss of the drop-outs during treatment was comparable (Δ-BMI −0.201 ± 0.440 (−0.288 to −0.115 per month treatment).

Self-treatment

To examine weight change of the patients who had terminated treatment prior to FU, the FU group was split into 80 patients who were treated continuously for the entire period and 333 patients who had a self-treatment period of variable length (Table 5). In 47% of the treatment group, physician-measured weight was obtained; in the others, it was self-reported. During ST, weight decreased further by a mean of −0.052 BMI points. Compared to those who were treated throughout total weight loss was 50% less. Interestingly, the comparison of weight loss per month of treatment showed no difference between these two groups (Table 5). Weight loss of the patients with physician-measured weight at follow-up (−0.055 BMI points) was not different from the group with self-reported weight (−0.049 BMI points).

For a more detailed analysis of the ST group, patients were divided according to weight loss, maintenance or weight gain, respectively (Table 6). Since in a substantial percentage of patients follow-up weight is based on self-reported data, weight maintenance was considered in the range of +1 to −1 kg compared to LV weight; 40% had further weight loss, from 110.6 ± 26.6 to 103.4 ± 25.3 kg, and 46% had maintained the weight loss achieved during the treatment phase and 14% had considerable weight gain from 106.0 ± 24.0 to 111.7 ± 24.6 kg (Table 6). The average treatment period was nearly identical in all three groups and the rate of weight loss during treatment was significantly lower in the losers compared to the maintenance group. Furthermore, total weight reduction of the patients with further ST weight loss was in the same range

Table 3 Weight change until the end of treatment in relation to class of body weight [mean ± SD (95% CI interval)]

Class of body weight	25–39.9 kg/m^2, $n = 310$	40–44.9 kg/m^2, $n = 88$	≥45 kg/m^2, $n = 116$
BMI baseline (kg/m^2)	32.2 ± 3.5 (32.8–33.6)	42.1 ± 1.4[a] (41.8–42.4)	51.2 ± 6.5[a] (50.0–52.4)
Δ-BMI per month of treatment	−0.162 ± 0.329* (−0.199 to −0.125)	−0.235 ± 0.434*,[a] (−0.326 to −0.144)	−0.250 ± 0.506*,[a] (−0.342 to −0.158)
Treatment period (months)	10.4 ± 11.2 (9.2–11.7)	9.4 ± 10.3 (7.3–11.6)	11.6 ± 13.3 (9.1–14.1)

* Significant difference of $p < 0.0001$ versus baseline; [a] versus BMI 25–39.9

Table 4 Weight change during the treatment period of those 413 patients who were reached at follow-up [mean ± SD (95% CI interval)]

Baseline BMI (kg/m^2)	39.0 ± 8.7 (38.2–39.8)
End of treatment	37.0 ± 8.2 (36.2–37.8)*
Δ-BMI per month of treatment	−0.193 ± 0.383 (−0.230 to −0.156)
Follow-up period (months)	29.0 ± 12.0 (27.8–30.1)

* Significant difference of $p < 0.0001$ versus basal

as that of the patients who were treated throughout, although the duration of treatment was only one-third.

Comorbidities

One hundred and sixty-four patients had type 2 diabetes mellitus (DM2) with a duration from newly discovered disease to >20 years of manifestation.

In the DM2 group, 22 (13.4%) patients were lost during follow-up compared to 78 non-diabetic subjects (22.3%). The rate of weight loss during treatment was not different between patients with and without diabetes. (Δ-BMI per month of treatment: −0.207 ± 0.349 (−0.260 to −0.153) vs. −0.189 ± 0.417 (−0.233 to −0.145); $p = 0.636$; however, during ST, the rate of weight loss was approximately four times greater in the DM2 group leading to an overall greater total weight loss in this group (−10.9 ± 10.4 vs. −5.9 ± 10.2 kg; $p < 0.0001$). (Δ-BMI per month of self-treatment: −0.106 ± 0.236 (−0.154 to −0.058) vs. −0.028 ± 0.106 (−0.042 to −0.014); $p < 0.0001$; Δ-BMI per month total: −0.158 ± 0.159 (−0.184 to −0.131) vs. −0.067 ± 0.106 (−0.080 to −0.055); $p < 0.001$. Hemoglobin A1c was reduced from 7.3 ± 1.6 to 6.7 ± 1.4% ($p < 0.0001$). At the time of follow-up, only five of the initially 39 patients with insulin treatment had to inject regular insulin occasionally to correct elevated blood glucose levels.

The 99 subjects treated with ß-blockers had no significantly different weight loss compared to the rest of the study population Δ-BMI per month of treatment: −0.179 ± 0.326 (−0.243 to −0.115); Δ-BMI per month total: −0.127 ± 0.151 (−0.159 to −0.094). Similarly, no difference of weight loss was detected for the patients with psychiatric medication Δ-BMI per month of treatment: −0.218 ± 0.384 (−0.337 to −0.100); Δ-BMI per month total: −0.101 ± 0.147 (−0.155 to −0.046).

Food intake

One hundred and eighty-nine patients provided dietary records at follow-up (84 with and 105 without type 2 diabetes) These records were compared with those obtained before the start of treatment. In this subgroup, weight changed from BMI 39.6 ± 9.0 to 35.8 ± 7.6 kg/m^2 ($p < 0.0001$) over an average follow-up period of 27.1 ± 12.8 months. Food intake was reduced by 10% from 1024 ± 286.5 to 927 ± 340.7 g/day ($p < 0.0001$). The number of meals per day was also significantly lower (3.87 ± 0.84 vs. 3.32 ± 0.66, $p < 0.0001$). Total energy intake (solid + liquid calories) was reduced by 568 kcal from 1736 ± 571.5 (1655–1817) to 1168 ± 433.3 (1106 to 1230) kcal/day. The change of solid food intake was −465 kcal/d (1585 ± 481.8 (1516–1654) vs. 1120 ± 410.6 (1061–1178) kcal/d). ED was reduced by 0.34 kcal/g from 1.58 ± 0.40 (1.52–1.63) to 1.24 ± 0.38 (1.18–1.29) kcal/g ($p < 0.001$). (6.60 ± 1.67 vs. 5.18 ± 1.59 kJ/g).

The macronutrients carbohydrate and fat were significantly reduced by 28 and 42%, respectively (carbohydrate: 173 ± 61.3 (164–181) vs. 125 ± 54.1 g/d (117–132) $p < 0.0001$); fat: 62 ± 25.2 (58–65) vs. 36 ± 15.3 g/d (34–38), $p < 0.0001$). Protein intake was moderately lower (−7%) 68 ± 20.7 (65–71) vs. 63 ± 26.3 g/d (59–66), $p = 0.0002$) (Fig. 1). The protein/carbohydrate ratio increased from 0.40 before to 0.50 after change of eating habits ($p < 0.0001$). Dietary fiber intake was also significantly lower after the change of eating habits (16.1 ± 5.5 (15.3–16.9) vs. 13.0 ± 8.5 (11.8–14.2) g/d, $p < 0.0001$). Fiber intake in relation to daily solid food intake increased slightly from 10.4 ± 2.6 (10.0–10.8) to 12.0 ± 8.9 (10.7–13.3) g/1000 kcal ($p = 0.014$). In relation to total energy intake of solid food carbohydrate-related energy intake remained unchanged, while fat-energy decreased significantly by 6% and protein-related energy increased by 5.3% (Fig. 1).

Figure 2 shows the contribution of food items with low, medium and high ED to daily food quantity and energy

Table 5 Weight change of the patients who had terminated treatment prior to follow-up (self-treatment group) in comparison with those who were still in treatment until FU [mean ± SD (95% CI interval)]

	Self-treatment-group, $n = 333$	Patients treated throughout, $n = 80$
BMI (kg/m^2)		
Basal	38.5 ± 8.0 (37.6–39.3)	41.2 ± 11.0 (38.8–43.6)[a]
LV	37.0 ± 7.9 (36.2–37.8)	36.8 ± 9.5 (34.8–38.9)
FU	36.3 ± 7.7* (35.5–37.2)	Identical with LV
Δ-BMI per month of self-treatment	−0.052 ± 0.163 (−0.070 to −0.035)	–
Δ-BMI per month (total)	−0.082 ± 0.131 (−0.097 to −0.068)	−0.164 ± 0.123 (−0.191 to −0.137)[a]
Δ-BMI per month treatment	−0.200 ± 0.424 (−0.246 to −0.155)	−0.164 ± 0.123 (−0.191 to −0.137)[n.s.]
Treatment period (months)	8.7 ± 10.0 (7.6–9.8)	25.9 ± 11.2 (23.5–28.4)[a]
Self-treatment period (months)	16.8 ± 10.0 (15.5–18.1)	–

* Significant difference of $p < 0.0001$ versus LV; [a] significant difference $p < 0.01$ or less between groups

Table 6 Differential weight loss of the self-treatment group [mean ± SD (95% CI interval)]

	Weight loss (>−1 kg)	Weight maintenance (−1 to +1 kg)	Weight gain (>+1 kg)
n	133; 40%	153; 46%	47; 14%
BMI LV (kg/m^2)	37.7 ± 8.5 (36.2–39.1)	36.5 ± 7.7 (35.3–37.7)	37.1 ± 6.8 (35.2–39.0)
BMI FU (kg/m^2)	35.2 ± 7.7* (36.9–36.5)	36.5 ± 7.7 (35.3–37.7)	39.0 ± 6.9*[,a] (37.0–41.0)
Δ-BMI per month treatment	−0.145 ± 0.384 (−0.211 to −0.080)	−0.244 ± 0.464[a] (−0.318 to −0.170)	−0.212 ± 0.381 (−0.321 to −0.103)
Δ-BMI self-treatment	−0.162 ± 0.193 (−0.195 to –0.129)	0.002 ± 0.026[a] (−0.006 to –0.002)	+0.095 ± 0.129[a] (0.058–0.132)
Treatment (months)	8.8 ± 10.0 (7.1–10.5)	8.8 ± 10.5 (7.1–10.4)	8.1 ± 8.0 (5.8–10.4)

Significant difference of $p < 0.05$ or less: * versus LV; [a] versus weight loss, [b] versus weight maintenance

intake. At baseline, high ED food contributed only 25% to food quantity but nearly 50% to energy intake. After change of eating habits, the greatest contribution to energy intake came from low ED food paralleled by a reduction of medium and high ED food.

Major contributions to the reduction of energy intake (kcal/d) came from the following food items (% of total reduction): bread:−103;(18.1), beverages: −102;(18.0), processed meat: −72; (12.7), chocolate: −71;(12.5), cake: −70;(12.5), butter: −62;(10.9) and cheese −32;(5.6), respectively.

Daily expenditures for food, based on prices in May 2007, were 5.32 ± 1.68€ before treatment and 4.93 ± 2.02€ afterward ($p = 0.0016$) corresponding to 0.53€/100 g food intake before and 0.54€/100 g after change of eating habits (n.s.). Treatment cost per month of treatment was 12.5 ± 9.2€ (11.7–13.3) based on the average (20 min per visit in relation to number of visits per month) counseling time of 29.5 ± 21.7 (27.6–31.4) min per month. The cost for each kg of weight loss was 26.25€ considering the treatment period and 17.25€ considering the total period including follow-up.

Discussion

The present analysis examines obesity treatment in a large and unselected population under conditions of every day clinical practice. In several aspects, the present population differs from the majority of study populations. Body weight was high due to 40% of the patients having BMI >40 kg/m^2 and almost 25% had BMI >45 kg/m^2. Most studies of dietary intervention have an upper limit of BMI 40 kg/m^2 with few studies including subjects up to BMI 45 kg/m^2 [11–15]. Furthermore, comorbidities and related drug treatment were not exclusion criteria. In most obesity trials, patients with psychiatric diseases and anti-depressant drugs, insulin-treated type 2 diabetes, and those with ß-blocker treatment are usually excluded.

Mean weight loss of −5.2 kg over 10.5 months is in the range of previously reported data. The meta-analysis of 46 trials of dietary counseling by Dansinger et al. [13] revealed a change in weight over time by −0.12 BMI units/month within a comparable time period, which is slightly less than the −0.195 BMI units/month of the present study. The meta-analysis of low-carb vs. low-fat diets by

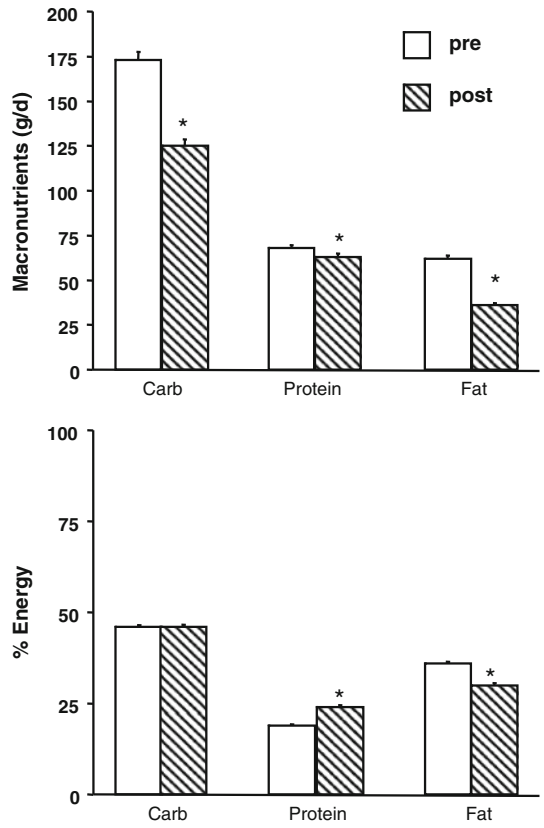

Fig. 1 Daily macronutrient intake (*upper panel*) and contribution of macronutrient-derived energy to total energy intake (*lower panel*) before (*pre*) and after change of eating habits at follow-up (*post*) (mean ± SEM; $n = 189$); *Significant difference of $p < 0.01$ or less

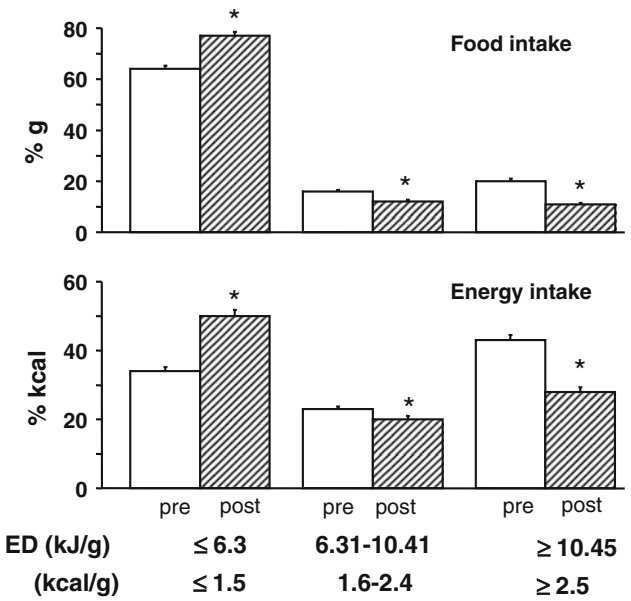

Fig. 2 Contribution of food items with low (≤1.5 kcal/g), medium (1.6–2.4 kcal/g) and high energy density (ED ≥ 2.5 kcal/g) to daily food and energy intake before (*pre*) and after change of eating habits at follow-up (*post*) (mean ± SEM; $n = 189$); *Significant difference of $p < 0.0001$ pre versus post

Nordman et al. [15] shows that the present weight loss is more in the range of the low-carb studies. Similarly five of the 19 studies summarized in the meta-analysis of low-fat diets by Astrup et al. [14] reported a weight loss of −5 to −8 kg while the other studies had an average weight loss of <4 kg. The analysis of mixed hypocaloric diets by Anderson et al. [11] including both low-fat and low-carb diets demonstrated weight loss of 6–8 kg over a treatment period of up to 6 months; 36% of our patients lost >5% of the initial body weight which is in the range of a number of previous intervention trials with various treatment modalities [6, 18, 45–52]. In all these studies, duration of treatment was clearly defined for all participants. Studies that were more related to "every day clinical practice" based on the weight watchers program had a similar loss during the first 6 months of the intervention [53]. This indicates that the treatment concept applied in these patients leads to comparable weight loss as reported previously.

In patients with extreme obesity, dietary and lifestyle or pharmacological interventions are usually not successful [54, 55] and accordingly patients with BMI >40 kg/m^2 are included only in a few studies [56–59]. The largest long-term trial with a mixture of dietary advice, behavior modification and physical activity is the SOS study where the non-surgical group had no weight loss over a comparable period of 2 years [60]. Extremely obese patients can lose weight with the present concept which is less compared to very low calorie diets. However, in contrast to the latter, it is not restricted to a limited time period [11, 61, 62].

Medication with ß-blockers can favor weight gain especially at the beginning of antihypertensive treatment while later on this effect is not apparent any more [63]. The vast majority of our patients took ß-blockers at least for several months which might explain that weight loss was not different.

Another important problem is psychiatric medication-induced obesity since the majority of available drugs will favor weight gain [64]. Despite this well-known problem, the subgroup of 40 patients had no different weight loss. We interpret the results in these patients cautiously since their number is fairly small and they had stable disease with no major exacerbations during the treatment period.

Obesity favors the development of type 2 diabetes mellitus (DM2) and weight loss can improve carbohydrate metabolism, produce a remission in diabetes and reduction in diabetes-related mortality [5, 6, 8, 65].

A meta-analysis of studies employing energy restricted diets between 800 and 1200 kcal/d revealed a weight loss of 11% after 1 year [65] which is comparable to the present data although it should be noted that baseline body weight was considerably lower (94 kg vs. 114 kg). In several studies, weight loss of DM2 patients was less compared to

obese non-diabetic subjects [66–69] while others have reported an identical weight loss [70] in accord with the present results.

Self-treatment and maintenance

The major therapeutic challenge is to maintain or even augment weight loss after cessation of treatment. As demonstrated previously, weight maintenance can be a problem already during the ongoing treatment phase in studies with dietary intervention [9] and additional drug treatment [10]. Accordingly, the recommended dietary changes must be appealing not only for weeks or months but rather for many years or a life-long management.

A meta-analysis of weight changes after the end of treatment shows consistently weight gain in the range of +0.02 to 0.03 BMI units per month [13], while the present concept supports further weight loss (−0.05 BMI units per month). A long-term treatment concept based on the weight watchers program has shown weight gain after the first 6 months despite ongoing consultation of the treatment centers [53]. A considerable proportion of the patient's weight is based on self-reported data but weight change in this group was not different from those with objective measurements. Furthermore, several previous studies have provided evidence that current weight and also recall of previous weight information is reliable [71–75]. Nevertheless, we have attempted not to over-interpret this information by defining weight maintenance in a range of ±1 kg.

The weight loss or maintenance during ST was independent of the treatment effect and the duration of treatment since both were largely comparable in all three groups. Interestingly, the losers had a small but significantly lower rate of weight loss during treatment compared to the maintainers. Whether the 100 patients who were lost during follow-up have great impact on the data remains speculative. At the end of the treatment phase, weight loss was not different from the other patients. Assuming that the entire group of 100 patients would have gained weight it would definitely affect the final outcome. However, there is no reason why this group should behave substantially different from the others. These "drop-outs" are lost during follow-up which is not comparable with drop-outs during a fixed study period which in general is indicative of bad compliance and failure.

A substantially better long-term result during self-treatment was observed in the DM2 patients which we ascribe to an increased motivation created by the perspective to lose a major life-threatening disease. These data are in accord with studies showing that DM2 patients have better long-term weight loss or at least maintenance compared to those without diabetes [76, 77] although the opposite effect has also been reported [69]. Nevertheless, the present data underline the importance of weight reduction as causal treatment of DM2 helping to reduce the need for insulin treatment substantially [65, 78].

Dietary concepts

Recommendations for a hypocaloric diet have considered each of the three macronutrients. Low-fat and a greater protein/carbohydrate ratio has led to successful weight loss [11–13, 16, 17, 21]. Low-carb diets have been shown to be at least as effective as low-fat diets with the advantage of allowing larger meal sizes [15, 19–21]. While the data of acute weight loss are very intriguing [50, 51], a major shortcoming is the poor long-term adherence to the low-carb concept [20, 79, 80] most likely due to the necessity of an approximately 10-fold reduction of habitual carbohydrate intake. Several studies have examined the role of protein in acute weight loss. On the basis of a fat-reduced diet high-protein (25%) resulted in a significantly greater short-term weight loss which, however, was not maintained [17, 18, 81–83]. In a short-term intervention, Westerterp-Plantenga et al. [84] showed a favorable effect of protein-enrichment on weight regain.

ED of food items has been shown to be an important parameter for the magnitude of acute energy intake [24–29]. The role of ED for energy intake proposed by these short-term data is supported by epidemiological evidence showing a strong association between ED and weight status [32–34]. On the other hand, it should be kept in mind that in free-living populations of normal weight and obese subjects short-term fluctuations of energy intake are only in part due to ED and substantially the result of increased meal size and frequency [43].

The efficacy of low ED diets has recently been demonstrated in several studies over a period of 6 months to 1 year [35–37]. In these studies, lower ED was accomplished by an energy—restricted, hypocaloric low-fat diet with additions of high or low ED food supplements in form of soup, snacks, vegetables, fruit or low-fat dairy products, respectively.

In the present concept, we have avoided fixed dietary prescriptions. These make the design of study concepts more comprehensive but when looking at the poor adherence in controlled studies [9] the effectiveness of such prescriptions remains rather doubtful.

Reduction of average daily energy intake was primarily attempted by recommending an exchange of food items with higher ED toward those with lower ED based on common availability and compatibility with the individual's preferences. Patients appreciate the option to select freely among a wide range of food items with the chance to counter-balance occasional or even regular intake of high

ED food on an individual basis. A major goal was to change as little as possible to raise the chances for an adoption of long-standing eating changes. The focus on ED does not exclude alterations of meal size and/or frequency and energy containing beverages as long as the patients feel satiated and satisfied. The transition of the recommendations from the treatment to the self-treatment phase has been successfully accomplished by a majority of patients as indicated by further weight loss or maintenance, respectively.

The focus on ED results in a combination of low-fat, low-carb and a higher protein/carbohydrate ratio without having to consider all these macronutrients separately, which can be helpful to reduce the number of decisions required for food choices.

The cost of treatment with the present concept is largely comparable to cost estimates in the Netherlands [85] and approximately half of the Swiss calculations [86].

The present data should be considered as a pilot study which suggests that an individually tailored change of eating habits could improve long-term weight loss. Food ED is a simple and easy to handle parameter in every day dietary counseling. From the present data, it is also evident that apart from food ED other factors such as reduction of beverages or number of meals contribute to lower energy intake. Based on these pilot data, the effectiveness needs to be evaluated in a controlled design to establish its validity in obesity treatment.

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