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## SPECIAL SELECTION: OBESITY

# Beyond weight reduction: Improvements in quality of life after an intensive lifestyle intervention in subjects with severe obesity

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**Introduction.** We examined the effects of 10–14 weeks of inpatient intensive lifestyle intervention (ILI), including a minimum of 90 minutes of adapted physical activity 5 days/week, with regard to changes in quality of life and associations with weight loss in subjects with severe obesity.

**Methods.** A total of 100 severely obese subjects (BMI  $42.6 \pm 5.3$  kg/m<sup>2</sup>;  $42.7 \pm 10.6$  years) were included. Quality of life was assessed by Binge Eating Scale, Hospital Anxiety, and Depression Scale, and SF-36. The ILI group completed the questionnaires at inclusion, after 10–14 weeks and 12 months, and controls at inclusion and after 10–14 weeks.

**Results.** Compared to controls, self-reported binge eating ( $-6.4$ ,  $P < 0.0001$ ), anxiety ( $-1.7$ ,  $P = 0.005$ ), and depression ( $-3.0$ ,  $P < 0.0001$ ) were reduced, and physical ( $8.0$ ,  $P < 0.0001$ ) and mental ( $7.6$ ,  $P < 0.0001$ ) health increased in the ILI group. After 12 months, reduction in self-reported binge eating ( $-7.2$ ,  $P < 0.0001$ ) and depression ( $-3.4$ ,  $P < 0.0001$ ) and increase in physical ( $8.9$ ,  $P < 0.0001$ ) and mental ( $3.6$ ,  $P = 0.035$ ) health were maintained. Decreased self-reported binge eating ( $\beta = 0.555$ ,  $P = 0.010$ ) and increased physical health ( $\beta = -0.554$ ,  $P = 0.003$ ) were associated with weight loss.

**Conclusion.** ILI including a high volume of physical activity in subjects with severe obesity improved quality of life by favorable changes in self-reported binge eating, depression, and mental and physical health. Improvements in binge eating and physical health were associated with weight loss.

**Key words:** Anxiety, binge eating, depression, health-related quality of life, morbid obesity, physical activity

## Introduction

Severe obesity as defined by a body mass index (BMI)  $\geq 40$  kg/m<sup>2</sup> or BMI 35–39.9 kg/m<sup>2</sup> with weight-related accompanying disease (1) is associated with an increased risk of physical co-morbidities (1,2) and psychosocial complications (1,3), including binge eating (3,4), anxiety, and depression (3,5–7). Physical and mental

## Key messages

- In severely obese subjects, a 10–14 week inpatient intensive lifestyle intervention, including a high volume of adapted physical activity, resulted in increased quality of life by favorable changes in self-reported binge eating, anxiety, and depression, as well as improvements in physical and mental health during the inpatient stay. The improvements in self-reported binge eating, depression, and physical and mental health were maintained after 1 year when the subjects were living at home.
- Reduced self-reported binge eating and increased physical health were associated with weight loss after 1 year.

health have a great impact on quality of life (3,4), and decreased health-related quality of life has been reported among severely obese subjects (3,4,7–11).

Studies have shown associations between physical activity and increased psychological well-being (12–14), reduced anxiety, reduced depression (14–17), and reduced symptoms of binge eating (18,19). Moreover, the relationship between physical activity, on the one hand, and depression and obesity on the other, has been shown to be bidirectional (20). Thus, physical activity may serve as protection from and reduction of obesity as well as depression. Recent research on subjects with severe obesity suggests that physical activity also supports weight loss through its effects on other psychosocial factors, i.e. improved self-efficacy, body satisfaction, mood, and eating habits (21–24). Clinically meaningful weight loss (25) in subjects with severe obesity has been shown following lifestyle interventions including different amounts of physical activity (26–32). However, the responses are generally graded by the intensiveness of the intervention (31,32). Studies investigating the impact of an intensive lifestyle intervention (ILI) with a high volume of physical activity on binge eating,

anxiety, depression, and physical and mental health in subjects with severe obesity are sparse (31–33).

One advantage of an inpatient treatment program is the good control of the intervention, in terms of dose-response in relation to physical activity, compliance with an energy-reduced diet, and the intensiveness of performed coping strategies with regard to changes in physical activity and eating behavior. Thus, the primary aim of this clinical controlled trial was to examine the acute and long-term effects of a 10–14-week inpatient lifestyle modification program, including a minimum of 90 minutes of physical activity 5 days per week, in terms of changes in quality of life assessed by self-reported binge eating, anxiety, depression, and physical and mental health in men and women with severe obesity. Our second aim was to study associations between changes in quality of life assessed by the same factors with weight status after 12 months.

## Material and methods

### Participants

This is a preplanned analysis of data from a clinical trial designed to examine the effects of a comprehensive inpatient lifestyle modification program for the treatment of severe obesity on body composition, cardiovascular disease risk factors, and psychosocial health (ClinicalTrials.gov-registry number NCT01675713). The study design, intervention, and participants have been described in detail previously (34,35). In summary, the study sample consisted of subjects referred to the Nimi Ringerike Obesity Clinic in Norway, for an inpatient stay of 10–14 weeks. Participants were 18–65 years old and had a BMI  $\geq 40$  kg/m<sup>2</sup> (or  $\geq 35$  kg/m<sup>2</sup> with weight-related co-morbidities) at the time of referring. The first part of the study was a non-randomized controlled clinical trial, where the intervention was a predefined comprehensive 10–14-week inpatient lifestyle intervention. The participants were then discharged and returned to the clinic for 1 week at approximately 6 and 12 months from baseline. In the second part of the study we prospectively followed the participants in the ILI group for 1 year from baseline. Individuals who did not complete the 10–14-week inpatient treatment program were not enrolled in the trial. A control group with waiting-list patients was included and followed for a 10–14-week time period comparable to the intervention. The Regional Committee for medical and health research ethics in Norway approved the protocol, and all the participants provided written informed consent. The study meets the standards of the Declaration of Helsinki. A previous report (35) showed a mean (95% confidence interval (CI)) 1-year weight loss of 15.6% (13.4%–17.8%). (Or optionally: –15.5% (–17.8%, –13.4%) of initial weight in the ILI group. The present analyses were based on 67 participants in the ILI group (44.8  $\pm$  10.4 years) and 33 in the control group (38.5  $\pm$  9.8 years) who enrolled in the study and completed the questionnaires related to binge eating, depression, anxiety, and physical and mental health at all measurement times.

### The intervention group

The lifestyle modification program focused on increasing the physical activity level, adjusting energy and nutrition intake, and learning coping strategies adapted to the subject's own challenges. The unique part of this treatment program was the very high volume of physical activity. During the inpatient period the participants typically took part in a minimum of 90 minutes of physical activity 5 days a week, i.e. two to three mandatory training sessions of 45 minutes each weekday. The exercise included aerobic (mostly indoor and outdoor bicycling, Nordic pole walking, and

dance/aerobic exercises), strength training (using machines or free weights), agility and balance training (yoga, pilates, bosu, and fitness balls), as well as different sport activities, games, and long walking tours. The activities were divided into low, moderate, and hard intensity and distributed during the week in a way that provided about the same total volume of physical activity each weekday, e.g. walking tours were longer in duration compared to the moderate- and high-intensity sessions. The training sessions were supervised by exercise scientists and physiotherapists. An adaptation of the physical activity to the participants included: 1) Training organized in three groups stratified by the results of an admission 10-m shuttle run test and time spent on a 750-m walk/run test, allowing participants to exercise in a group of people of approximately the same physical fitness. 2) Low-intensity continuous aerobic exercise during the first 2–3 weeks and then a gradual progression of duration and intensity. 3) The type of exercise chosen was intended to decrease the risk of injuries, e.g. spinning was used to relieve stress on the joints; strength training as well as yoga and pilates were used to train the core musculature. 4) Some specially adapted equipment was used (e.g. larger bike seats). In addition the majority of the subjects undertook training sessions (e.g. brisk walking) on their own before breakfast and in the evenings, and the participants were encouraged to work out during the weekends. Breakfast and lunch were served as buffets, and dinner was portioned and served on plates. A nutritionist demonstrated portion sizes according to restricted energy levels (1900 kcal/d for men and 1600 kcal/d for women), and the macronutrient composition of the diet was planned to be < 30 E% from fat, < 20 E% from protein, and 50–60 E% from carbohydrates. The subjects also participated in theoretical lectures and group sessions focused on principles of self-regulation, goal-setting, weekly planning, and evaluation.

### The control group

The subjects were waiting-list controls, received no treatment, and were given no advice regarding lifestyle changes during the intervention period of the study. However, following the 10–14 week control period these controls received the same inpatient treatment program as the ILI group. Severely obese subjects seeking treatment should, according to Norwegian guidelines, be offered either conservative or surgical therapy (36). We therefore did not follow the control group for 12 months, as we considered it unethical to keep the participants on the waiting list (in a control group) instead of offering these people available treatment at the clinic.

### Measures

At each examination, current body weight was measured (using Direct Segmental Multifrequency bioelectrical impedance, Inbody 720, Body Composition Analyzer, Biospace Co. Ltd). The change in body weight was used in the analyses. To assess quality of life the participants completed the following questionnaires independently: the Binge Eating Scale, the Hospital Anxiety and Depression Scale, and The Medical Outcome Study 36-Item Short Form Health Survey.

### Self-reported binge eating

For measuring self-reported binge eating we used the Binge Eating Scale, a questionnaire designed to assess the severity of binge eating in obese subjects, considering the behavioral manifestations of a binge and the feelings that follow a binge (37). The Binge Eating Scale consists of 16 sets of 3–4 statements that reflect a range of severity for each characteristic, and the subject is asked to endorse the one item from each set which best describes his or her eating

behavior. The statements are independently assigned scores from zero (0) to three (3), and a total score was calculated by summing the scores for the 16 individual statements. The total Binge Eating Scale score ranged from zero to 46, with high scores indicating more severe binge eating problems (37). The Binge Eating Scale has also been proposed as a screening tool for the diagnosis of binge eating disorder, and according to previous studies (38,39) a score of 18 or more is suggestive of binge eating disorder (suggestive binge eaters), and scores of 17 or less are suggestive of the absence of binge eating disorder (non-binge eaters).

### Anxiety and depression

Information on anxiety and depression was assessed by The Hospital Anxiety and Depression Scale, a self-assessment scale developed to detect states of depression and anxiety (40). The Hospital Anxiety and Depression Scale consists of 14 questions: seven assessing anxiety and seven assessing depression. The questions are scored on a four-point scale from zero (not present) to three (considerable). The scores are added and divided into sub-scale scores on the anxiety sub-scale and the depression sub-scale ranging from zero to 21. Lower scores represent better mental health with regard to anxiety and depression, and a score of eight or more on the sub-scales indicates 'possible cases' of anxiety disorders and/or depression (40,41). The Hospital Anxiety and Depression Scale is shown to be well suited for assessing the symptom severity and caseness of anxiety and depression in the general population and in somatic, psychiatric, and primary care patients (41) and has shown a good responsiveness to change in subjects with severe obesity undergoing bariatric surgery (42).

### Physical and mental health

We used a modified Norwegian version 2.0 of the SF-36 (SF-36v2) (43) to assess the quality of physical and mental health. The SF-36 is a well-established self-administered generic measure of the health burden of chronic diseases. The questionnaire consists of 36 items, with eight sub-scales of which four reflect components of physical health (Physical Functioning, Physical Role Limitation, Bodily Pain, General Health) and four reflect components of mental health (Vitality, Social Functioning, Emotional Role Limitation, and Mental Health). Subjects are asked about activities they might do during a typical day, and whether their health has reduced their ability to do these activities during the last 4 weeks. The two summary scores, the physical component summary and the mental component summary, were used as outcome variables in this study (44). Each summary scale ranges from zero (poorest, worst possible health state) to 100 (optimal, best possible health state); a higher score on both summaries represents better quality of physical and mental health (43).

### Statistical analysis

Data are reported as mean (standard deviation) or (95% CI), or number (%). Independent-samples *t* tests, Mann-Whitney *U* test, and chi-square test were used as appropriate to compare groups. Likewise, paired-samples *t* tests and Wilcoxon rank tests were used to assess changes within the ILI group. All tests were two-sided, and statistical significance was accepted when  $P < 0.05$ . There were small changes in the *P* values, and hence no change in the conclusion, using non-parametric tests. Thus, data are reported as mean with *P* values from parametric tests unless stated otherwise. There were no gender differences in relation to baseline scores or changes in scores on psychosocial health (data not reported). Cochran's *Q* test was used to assess change in the proportion of participants characterized as suggestive binge eaters, and in cases of anxiety and depression across the four measurement time

points: week 0, week 10–14, and 6 and 12 months. Only subjects measured at all four measurement times and with satisfactory completion of each questionnaire (i.e. in accordance with the scoring manuals for the Binge Eating Scale, The Hospital Anxiety and Depression Scale–Anxiety, The Hospital Anxiety and Depression Scale–Depression, the physical component summary, and the mental component summary of the SF-36) were included in the analysis for each variable, and hence the participants included (*n*) vary from variable to variable. To explore further the possible associations between changes in factors assessed for quality of life and changes in weight we used univariate general linear model (GLM). Changes in weight (differences in weight between baseline and week 10–14 or 12 months) were used as dependent variables, and changes in binge eating, anxiety, depression, and physical and mental health scores (differences in scales from baseline to week 10–14 or 12 months) as independent variables. In addition, the analyses were performed controlling for age, gender, and education. Data were analyzed using SPSS software version 18.0 (SPSS Inc., Chicago, IL, USA). As reported previously, drop-out analysis showed neither any significant differences in baseline characteristics, nor in weight reduction from week 0 to week 10–14, between completers and non-completers within the ILI group. There was, however, a smaller body weight reduction in the drop-outs than in the completers between weeks 10–14 and 6 months ( $-3.8$  (95% CI:  $-6.2$  to  $-1.3$ ) kg,  $P = 0.003$ ). No significant differences were found at baseline or in changes regarding binge eating, depression, anxiety, and physical and mental health quality.

## Results

### Baseline characteristics

Group-specific baseline characteristics of the participants are shown in Table I. No significant differences were found between the two study groups in terms of gender, body weight, education, mental health, or quality of life. However, the participants in the

Table I. Characteristics of participants at baseline in the intensive lifestyle intervention (ILI) group and the control group. Data are given as mean values (standard deviation) or number of subjects and percentages.

	ILI ( <i>n</i> = 67)		Control ( <i>n</i> = 33)		<i>P</i> value
	<i>n</i>	%	<i>n</i>	%	
Female/Male	43/24	64.2/35.8	21/12	63.6/36.4	0.958 <sup>a</sup>
Age (y)	44.8	(10.4)	38.5	(9.8)	0.005 <sup>b</sup>
Height (cm)	172.1	(8.5)	172.3	(10.4)	0.925 <sup>b</sup>
Body weight (kg)	126.3	(20.3)	127.1	(21.6)	0.865 <sup>b</sup>
Body mass index (kg/m <sup>2</sup> )	42.5	(4.8)	42.8	(6.3)	0.762 <sup>b</sup>
BES	15.3	(7.7) <sup>c</sup>	15.7	(8.7)	0.808 <sup>b</sup>
HADS-A	6.2	(4.0) <sup>d</sup>	7.0	(4.4)	0.424 <sup>b</sup>
HADS-D	4.9	(3.8) <sup>d</sup>	4.3	(3.5)	0.459 <sup>b</sup>
SF-36 PCS	41.0	(9.0) <sup>e</sup>	42.1	(9.0)	0.585 <sup>b</sup>
SF-36 MCS	45.2	(12.1) <sup>e</sup>	44.7	(12.2)	0.843 <sup>b</sup>
Highest education					0.074 <sup>a</sup>
Primary and/or secondary school	7 <sup>d</sup>	11.9	7	21.2	
High school	28 <sup>d</sup>	47.5	20	60.6	
Higher education	24 <sup>d</sup>	40.7	6	18.2	

BES = Binge Eating Scale; HADS-A = Hospital Anxiety and Depression Scale–Anxiety; HADS-D = Hospital Anxiety and Depression Scale–Depression; SF-36 PCS = SF-36 Physical Component Summary; SF-36 MCS = SF-36 Mental Component Summary.

<sup>a</sup>Chi-square.

<sup>b</sup>Independent samples *t* test.

<sup>c</sup>*n* = 61.

<sup>d</sup>*n* = 59.

<sup>e</sup>*n* = 57.

ILI group were on average 6 years older than those in the control group.

### Changes in quality of life

Compared to the control group, a reduction in self-reported binge eating ( $-6.4$ ,  $P < 0.0001$ ), depression ( $-3.0$ ,  $P < 0.0001$ ), and anxiety ( $-1.7$ ,  $P = 0.005$ ), and an increase in physical ( $8.0$ ,  $P < 0.0001$ ) and mental ( $7.6$ ,  $P < 0.0001$ ) health were seen in the ILI group from baseline to week 10–14 (Table II).

The prospective part of the study from week 0 to 12 months within the ILI group showed significant reductions in the Binge Eating Scale ( $-7.2$ ,  $P < 0.0001$ ) and in the depression scores ( $-3.4$ ,  $P < 0.0001$ ). An increase in the physical health ( $8.9$ ,  $P < 0.0001$ ) and mental health summary scores of the SF-36 ( $3.6$ ,  $P = 0.035$ ) were seen during the same period. The main changes occurred during the intervention period and remained fairly stable thereafter (Figure 1).

The proportion of 'suggestive binge eaters', 'possible cases anxiety', and 'possible cases depression' were reduced significantly (all  $P < 0.005$ ) within the ILI group across the four time points (Figure 2).

### Associations between changes in quality of life and weight loss

Table III shows the associations between changes in weight and changes in quality of life variables. Decreased self-reported binge eating ( $\beta = 0.555$ ,  $P = 0.010$ ) and increased physical quality of health ( $\beta = -0.554$ ,  $P = 0.003$ ) were associated with weight loss after 12 months.

### Discussion

The novel finding of the present study was that severely obese men and women participating in a 10–14 week inpatient ILI, with at least 90 minutes of physical activity on 5 days per week performed in a controlled setting, improved their quality of life during the inpatient stay by reduced self-reported binge eating, reduced depression and anxiety, and increased physical and mental health. With the exception of anxiety, the positive improvement in eating behavior and physical and psychological parameters was maintained for a full year. Moreover, reduction in self-reported binge eating and increased physical health were associated with weight reduction after 12 months.

This is in line with findings that improvements in eating behavior are associated with weight loss and weight loss

maintenance (35,45–47), and that obese individuals in treatment experience reduced symptoms of depression (48). The present findings are also consistent with previous research suggesting a relationship between weight loss and improvements in physical health-related quality of life in subjects with severe obesity undergoing ILI (31,32). In our study, the 1-year weight loss was greater than for shorter inpatient and day patient lifestyle interventions (26–30,32,49). Probably the long inpatient period has provided more time for the severely obese participants to establish new eating and exercise habits (50). In addition, previous studies have not included such a strong and controlled physical activity component in their interventions. This might explain the greater weight reduction (28,51) as well as improvements in quality of life seen in the present study. Exercise is shown to improve quality of life independent of weight change (52). In their randomized trial Goodpaster et al. (28) found an almost 3-kg greater weight reduction at 6 months when 60 minutes of moderate intensity physical activity 5 days per week were included in their ILI for the treatment of severe obesity, compared to those without physical activity. According to the formula for energy expenditure and intake published by Hall et al. (51) the minimum of 90 minutes of physical activity on 5 days per week included in the present ILI has caused an approximately 5-kg greater weight reduction during the inpatient period, assuming no compensatory changes in energy intake. Compensatory behavior, such as increased energy intake or less energy expenditure, is less likely to have occurred during the controlled setting during participants' inpatient stay.

### Changes in self-reported binge eating and weight loss

The finding that change in binge eating was significantly associated with change in weight is in accordance with a study of moderately obese women (53), indicating that reducing binge eating may be a key factor for maintaining weight reduction. Also in overweight and obese individuals with type 2 diabetes participating in an ILI, a greater weight loss at 1 year was observed in participants who stopped binge eating (54). Likewise, in a report from The National Weight Control Registry, weight gainers showed greater increase in binge eating than maintainers (55). Physical activity has been shown to increase the sensitivity for satiety signals (56–58) and the satiating efficiency of a fixed meal (59), and to influence weight control indirectly through eating self-regulation and fewer overeating episodes (21,22,24,60). In our study the prevalence of suggestive binge eaters was reduced during the inpatient period, but change in binge eating explained only 9.6% of the variation in weight reduction. This indicates that change in reduced episodes of binge eating represents a small proportion of the variation in weight loss. Other known contributing factors are BMI, age, gender, and socio-economic status, as also shown in the adjusted analysis.

### Changes in anxiety and depression and weight loss

The significant reduction in mean depression score at 12-month follow-up indicates a positive long-term effect of the ILI among men and women with severe obesity. This is in line with findings from weight loss trials including obese individuals with and without psychological co-morbidities (33,48). Regular physical activity is related to fewer and less severe depression and anxiety symptoms, and physical activity has been shown to be associated with decreased symptoms of depression and anxiety (17,61–63). The mechanisms responsible for the effect of the exercise on anxiety and depression are probably through positive impact on a number of physiological and psychological mechanisms (61,63). Hence it is reasonable to believe that the high volume of adapted physical activity included in our inpatient program might partly

Table II. Between-group differences in changes in binge eating, mental health, and quality of life variables from week 0 to week 10–14. Data are mean values (standard deviation or 95% CI).

	ILI	Control	Between-group differences, Mean (95% CI)	<i>P</i> value <sup>a</sup>
BES	-7.7 (7.2) <sup>c</sup>	-1.2 (6.6) <sup>b</sup>	-6.4 (-9.4, -3.4)	$P < 0.0001$
HADS-A	-1.6 (3.0) <sup>d</sup>	0.2 (2.2) <sup>b</sup>	-1.7 (-2.9, -0.5)	$P = 0.005$
HADS-D	-2.5 (3.1) <sup>d</sup>	0.5 (1.7) <sup>b</sup>	-3.0 (-4.0, -2.0)	$P < 0.0001$
SF-36 PCS	8.0 (6.3) <sup>c</sup>	-0.1 (5.8) <sup>b</sup>	8.0 (5.4, 10.7)	$P < 0.0001$
SF-36 MCS	7.7 (11.1) <sup>c</sup>	0.0 (7.1) <sup>b</sup>	7.6 (3.8, 11.5)	$P < 0.0001$

BES = Binge Eating Scale; HADS-A = Hospital Anxiety and Depression Scale-Anxiety; HADS-D = Hospital Anxiety and Depression Scale-Depression; SF-36 PCS = SF-36 Physical Component Summary; SF-36 MCS = SF-36 Mental Component Summary.

<sup>a</sup>Independent samples *t* test.

<sup>b</sup> $n = 33$ .

<sup>c</sup> $n = 61$ .

<sup>d</sup> $n = 59$ .

<sup>e</sup> $n = 57$ .

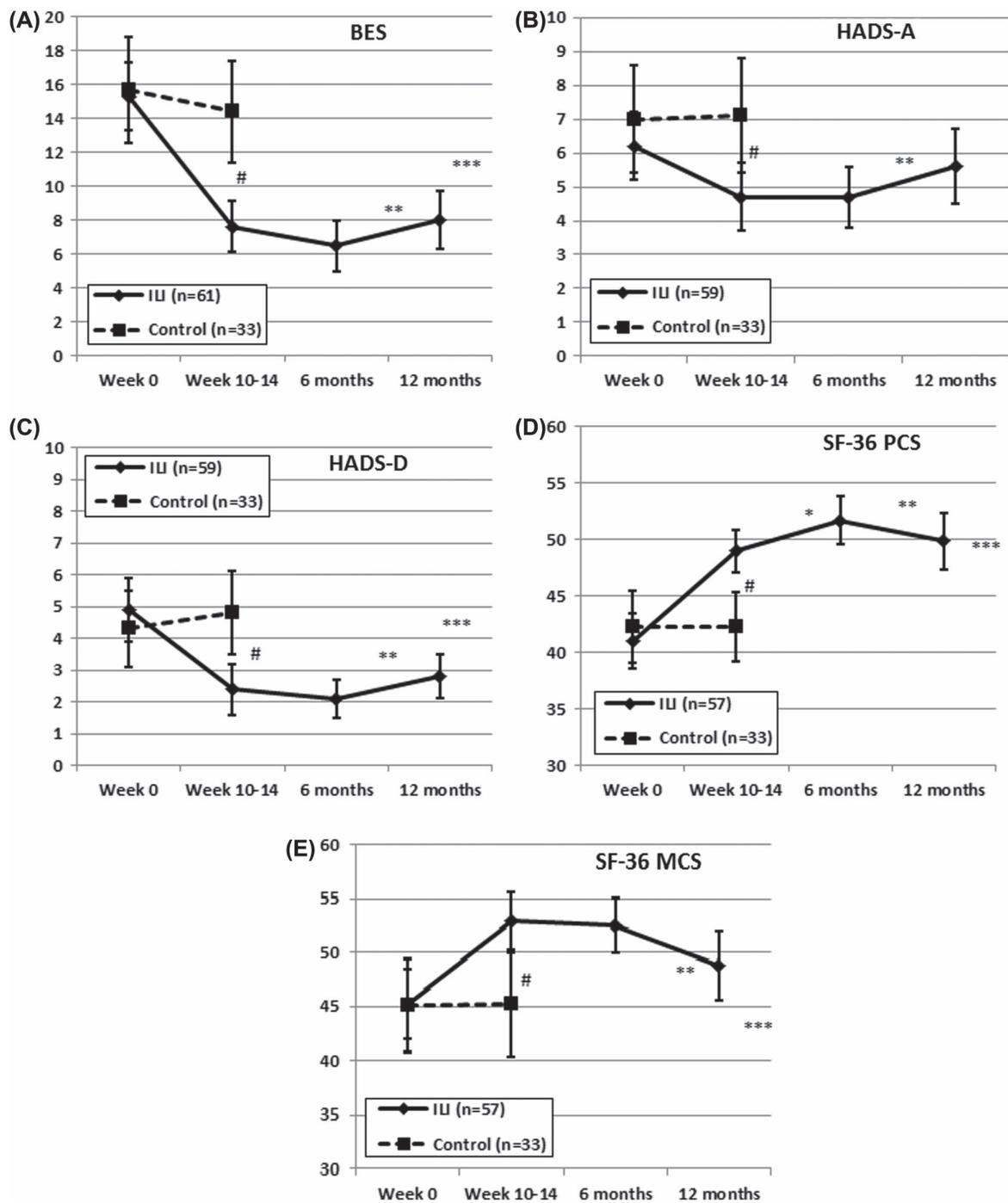


Figure 1A-E: Mean (95% CI) scores of quality of life (self-reported binge eating (A), anxiety (B), depression (C), physical (D) and mental (E) health) during the study period in the intervention and the control group <sup>#</sup> $P < 0.006$  for differences in changes between ILI-group and controls, <sup>\*</sup> $P = 0.001$  for changes within the ILI-group from week 10-14 to six months, <sup>\*\*</sup> $P < 0.03$  for changes within the ILI-group from six to 12 months, <sup>\*\*\*</sup> $P < 0.04$  for changes within the ILI-group from week 0 to 12 months. Abbreviations: BES = Binge Eating Scale, HADS-A = Hospital Anxiety and Depression Scale - Anxiety, HADS-D = Hospital Anxiety and Depression Scale - Depression; SF-36 PCS = SF-36 Physical Component Summary; SF-36 MCS = SF-36 Mental Component Summary.

explain the observed improvements in symptoms of anxiety and depression during the inpatient stay. However, in a study among women with obesity grade 1, the combination of physical activity and energy-reduced diet, and not physical activity alone, was responsible for the improvements in depression scores (64). Hence it may be the overall ILI, not only the adapted physical activity, that had the positive impact.

Our finding that depression was reduced more than anxiety is in agreement with findings in severely obese subjects following

bariatric surgery (64). Moreover, subjects undergoing bariatric surgery remain anxious, which is partly due to worries about regaining weight (65). This might be the case for the subjects in the present study too, after participating in an inpatient ILI program. The finding that anxiety was significantly reduced during the 10-14 week inpatient period, but not sustained for 12 months, might be explained by causes such as experiencing psychological stress related to participants' return to real life at home, including body dissatisfaction, eating problems, the fear of exercising in public

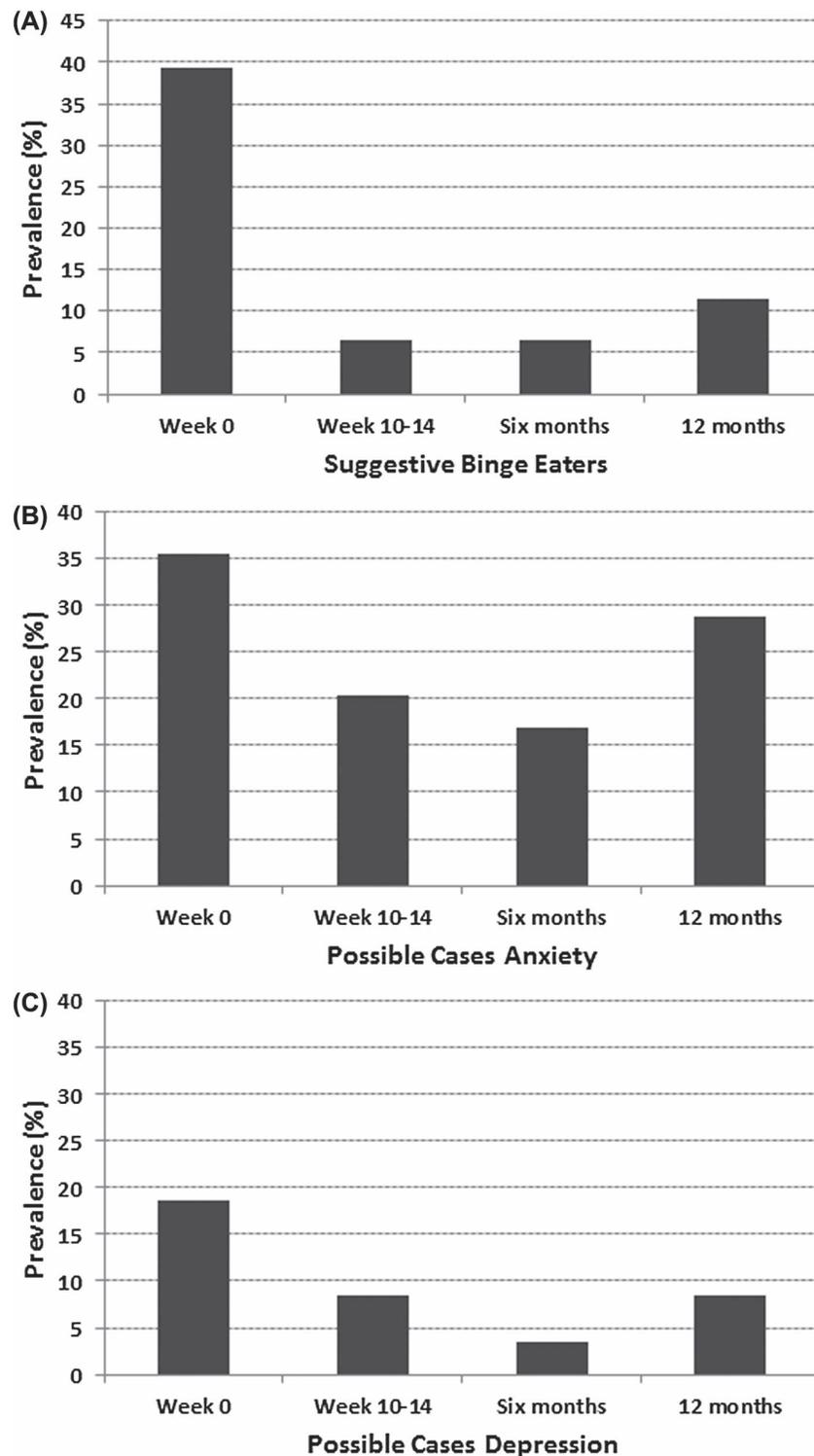


Figure 2A–C: The prevalence of suggestive binge eaters (A,  $n = 61$ ), possible cases of anxiety (B,  $n = 59$ ) and depression (C,  $n = 59$ ) within the ILI-group at Week 0, week 10–14, six and 12 months. All  $P < 0.005$  for change in the proportion of participants characterized as suggestive binge eaters and possible cases of anxiety disorders and depression across the four measurement time points.

and together with normal-weight people, social relations, socio-economic factors, stigmatization, and discrimination (64,66–71).

The finding that changes in anxiety and depression scores were not associated with change in body weight is also in line with findings of subjects with severe obesity undergoing bariatric surgery (64). However, these findings are in contrast to others in which increases in depressive symptoms were associated with less

weight loss or renewed weight gain (72,73). The empirical evidence regarding the association between depression and weight loss is mixed and varies according to measurement pre- or post-treatment, at follow-up, or as changes in depression, as well as whether weight loss or maintenance is reported. Several studies have reported no relationship, or even a positive relationship, between depression and weight maintenance (74–76). In this regard

Table III. Associations between weight change and changes in binge eating and health-related quality of life.

Independent variables and model	n	B	95% CI	Adjusted R <sup>2</sup>	P value
$\Delta$ BES week 0 to 10–14	61	0.222	0.018, 0.425	0.059	0.033
Adjusted <sup>a</sup>	54	0.170	–0.033, 0.372	0.067	0.098
$\Delta$ HADS-A week 0 to 10–14	59	0.038	–0.491, 0.567	–0.017	0.887
Adjusted <sup>a</sup>	53	–0.067	–0.586, 0.452	0.030	0.797
$\Delta$ HADS-D week 0 to 10–14	59	0.077	–0.424, 0.578	–0.016	0.759
Adjusted <sup>a</sup>	53	0.105	–0.408, 0.618	0.032	0.683
$\Delta$ SF-36 PCS week 0 to 10–14	57	–0.334	–0.578, –0.091	0.105	0.008
Adjusted <sup>a</sup>	50	–0.351	–0.588, –0.113	0.164	0.005
$\Delta$ SF-36 MCS week 0 to 10–14	57	0.146	0.004, 0.289	0.055	0.044
Adjusted <sup>a</sup>	50	0.142	–0.002, 0.286	0.080	0.053
Dependent variable: $\Delta$ Weight week 0 to 12 months					
$\Delta$ BES week 0 to 12 months	58	0.555	0.136, 0.974	0.096	0.010
Adjusted <sup>a</sup>	51	0.548	0.116, 0.981	0.062	0.014
$\Delta$ HADS-A week 0 to 12 months	56	–0.443	–1.635, 0.749	–0.008	0.460
Adjusted <sup>a</sup>	50	–0.621	–1.844, 0.602	–0.050	0.312
$\Delta$ HADS-D week 0 to 12 months	56	–0.045	–1.209, 1.119	–0.018	0.939
Adjusted <sup>a</sup>	50	0.412	–0.855, 1.679	–0.065	0.516
$\Delta$ SF-36 PCS week 0 to 12 months	54	–0.554	–0.915, –0.193	0.138	0.003
Adjusted <sup>a</sup>	47	–0.548	–0.945, –0.151	0.095	0.008
$\Delta$ SF-36 MCS week 0 to 12 months	54	0.153	–0.122, 0.427	0.005	0.269
Adjusted <sup>a</sup>	47	0.087	–0.205, 0.378	–0.063	0.552

$\Delta$  = change from baseline to week 10–14 or 12 months; BES = Binge Eating Scale; HADS-A = Hospital Anxiety and Depression Scale–Anxiety; HADS-D = Hospital Anxiety and Depression Scale–Depression; SF-36 PCS = SF-36 Physical Component Summary; SF-36 MCS = SF-36 Mental Component Summary.

<sup>a</sup>Adjusted for age, gender, and education.

it seems important to have in mind that depression and anxiety are affected by many complex psychosocial factors (71,77,78), and in subjects with severe obesity psychological problems may be attributed to their characters (79,80).

### Changes in physical and mental health and weight loss

The significant improvements in both the physical and mental health components in the ILI group are in accordance with two recent studies of inpatient ILI in subjects with severe obesity (31,32). However, we found greater improvements in the physical component than seen in the study by Karlsen et al. (31); this may be due to the length of the inpatient stay and greater weight loss.

Surprisingly, we found that a decrease in mental health during the inpatient period was associated with reduction in body weight. This is in contrast to the negative association between weight loss and mental health reported by Karlsen et al. (31). In subjects with severe obesity, psychological parameters have been shown to be influenced by personal and environmental factors, social support, self-confidence, self-esteem, and coping strategies (8), and having paid work and social support are shown to be predictors of quality of life (81). The inpatient treatment program with high volume of adapted physical activity might have led to greater enhancement in physical health, even if environmental factors at home have not changed. Thoughts and feelings regarding how to manage eating habits and physical activity levels at home after the inpatient period might have been more stressful for subjects who achieved the most pronounced weight reduction. Our participants completed the questionnaires on the last day of the inpatient period, and the conditions might have been experienced as stressful. However, it is important to consider the specific 10–14-week inpatient intervention the participants have experienced. In relation to the internal validity of the questions included in SF-36, the questionnaire is related to the participants' experience during the past 4 weeks, the last weeks of the inpatient stay, a time period during which they have neither been at work nor had much housework to do. We could speculate that our participants doubted or wondered

whether they could continue the lifestyle changes and weight reduction on their own at home.

### Strengths and limitations

The main strengths of this study were the controlled ILI during the inpatient period and the inclusion of a control group during the first 10–14 weeks. One of the benefits of an inpatient treatment is its controlled setting; the adapted physical activity sessions were mandatory, and most of the meals were served. We were thereby able to assess the changes in quality of life in a weight loss intervention that included a high volume of adapted physical activity. The study has some limitations. First, we did not objectively measure physical activity level, and hence we cannot determine how much of the improvements in psychosocial health can be attributed to exercise or to other factors—for example, self-efficacy. Neither did we assess the total energy expenditure of the training program, or the amount of exercise and other activities that subjects performed during their leisure time. We have examined the effect of a lifestyle intervention program as a whole. A better design examining the effects of physical activity would have been to include two groups with randomization into physical activity versus non-physical activity, but this is not feasible in practice with the established treatment options for patients with severe obesity in Norway (36). Second, we did not measure binge eating, anxiety, and depression using clinical interviews, but the questionnaires used are highly validated and frequently used in the evaluation of obesity treatment (37,38,41,42,82). Small modifications made without approval of OptumInsight Life Sciences (QualityMetric) to the SF-36v2 may threaten reliability and validity, and hence the possibility of comparing results to other data or normative data. However, all response items do match the QualityMetric version of the SF-36v2, Standard (4-week) Recall Norwegian Health Survey. Third, the present study showed changes in mental health and quality of life components for a relatively short time period. Longer follow-up is required to investigate whether the observed improvements persist over a longer time period. Finally, we did not

control for possible changes in the lifestyle of the control group, which might have influenced the outcome of the study. Still, the results showed no changes in weight or quality of life scores, indicating no changes in lifestyle within the control group.

The participants in the study may not be representative of all subjects with severe obesity. Subjects with severe obesity do not constitute a homogeneous population with respect to psychological characteristics and components of quality of life (3). A number of distinct subgroups can be identified (3,11,83), and the generalizability of the findings in this study may be limited to the subgroup of severe obesity subjects referred to an inpatient ILI program. Due to a relatively small sample size the sample was not stratified according to age groups. This is a limitation of the study as the age might influence both the presence of depression and physical co-morbidities, and hence be a confusing factor. However, adjusting for age in the GLM analysis resulted in the same estimates. There is also a potential risk that those who were able to follow the program were the ones with the best skills to change their behavior and lose weight. This was indicated by the drop-out analysis showing a smaller weight reduction in the drop-outs compared to the completers between weeks 10–14 and 6 months.

### Implications and/or applications of the findings

Our results suggest that an ILI with a high volume of adapted physical activity, as performed in the present study, may lead to a reduction in binge eating important for weight reduction, clinically relevant (84) reduction in depression, as well as a large increase in physical quality of life, in subjects with severe obesity. Moreover the importance of the multiple components included in the treatment program should be emphasized: 1) The subjects lived at the clinic for at least 10 weeks, providing time to establish new eating and exercise habits; 2) The multidisciplinary team included a medical doctor, a psychologist, a clinical nutritionist, nurses, exercise scientists, and physiotherapists; and 3) The adapted physical activity was supervised by exercise scientists and physiotherapists and introduced a variety of different exercise activities, allowing the subjects to experience mastery and enjoy physical activity together with other severely obese subjects. This is of importance because increased body weight, reduced mobility, and medical problems have been used to explain why subjects with severe obesity often have experienced difficulties with physical activity (69,70,85,86).

### Conclusion

The current study showed that an intensive inpatient lifestyle intervention with a high volume of adapted physical activity improved quality of life by reduced self-reported binge eating and depression, and improved physical and mental quality of life, in subjects with severe obesity. The main changes occurred during the 10–14 weeks of the inpatient intervention period and remained relatively stable for the first year after treatment. Decreased self-reported binge eating and improved physical health were associated with long-term weight loss and seem to be important for weight loss maintenance. More research is needed to examine the flow of causal relationships between the improvement in quality of life and the physical activity. They nourish each other.

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