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ORIGINAL COMMUNICATION

Little effect of physical training on body composition and nutritional intake following colorectal surgery—a randomised placebo-controlled trial

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Objective: Postoperatively patients have a reduction in nutritional intake and body weight. We studied the effect of postoperative physical training on nutritional intake and body composition.
Methods: Patients ⩾60 y admitted for elective colorectal surgery were randomised to train muscular strength (group A) or to nonstrengthening exercises (group B) for 3 months. Fat mass (FM) and lean body mass (LBM) were assessed with bioimpedance preoperatively, 7, 30, and 90 days postoperatively. Nutritional intake was registered in a subpopulation.
Results: Of 119 included patients, 60 were randomised to group A and 59 to B. The changes in LBM at postoperative day 7 were a mean (s.d.) of 0.4 (2.1) kg in group A compared to −0.7 (2.0) kg in B. The difference between groups of 1.2 (0.5) kg at day 7 was statistically significant ($P=0.03$). At no other time was observed difference between groups in weight, LBM, or FM. The energy and protein intake rose during postoperative day 1–7 and rose further after discharge. At no time were differences between groups.
Conclusion: Physical training had little effect on body composition following abdominal surgery. The nutritional intake in well-nourished patients did not increase by training.
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Keywords: postoperative care; nutrition assessment; body composition; randomised controlled trial; exercise

Introduction

Major surgery elicits a metabolic stress response (Hill *et al*, 1993; Desborough, 2000) and postoperatively patients have a reduced oral nutritional intake (Hill *et al*, 1993; Ulander *et al*, 1998), loose body weight, fat mass (FM), and lean body mass (LBM) (Christensen & Kehlet, 1984; Hill *et al*, 1993). Concomitantly they will be less physically active and have a reduction in physical performance (Jensen & Hessov, 1997a; Henriksen *et al*, 2002a). Following uncomplicated surgery, patients will increase their nutritional intake during the first postoperative days (Henriksen *et al*, 2002b) and the body mass and physical performance will be at the premorbid level within months to a year in most patients (Hill *et al*, 1993; Henriksen *et al*, 2002a).

Weight loss, loss of LBM, and a deterioration in physical performance will often follow disease and surgery, but the loss of body mass and reduction in physical performance are not necessarily related. The exact weight loss that will lead to deterioration in physical function is not known, but it has been speculated that in elective surgical patients the weight loss has to exceed at least 4 kg before a reduction in physical performance can be anticipated in an average patient (Jensen & Hessov, 2000).

The effect of exercise on nutritional intake was recently studied in 20 malnourished elderly. They were fed enterally at night and were randomised to a 3-week program of treadmill walking or to no training. Despite similar nutritional intakes in the two groups, only the training group had a significant weight increase (Bermon *et al*, 1997).

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To our knowledge, the effect of postoperative physical training on the nutritional intake and the postoperative loss of weight and LBM has not been studied. The aim was therefore to study whether randomisation to intervention with physical training would lead to an increased nutritional intake and smaller weight losses postoperatively compared to daily nonstrengthening placebo activities.

Methods

Patients at or older than 60 y submitted to one of three Danish surgical departments from March 1999 to November 2001 for elective, abdominal colorectal surgery were invited to participate. Excluded were patients who lived more than 40 km from the hospital, those with inflammatory bowel disease, disseminated cancer, significant psychiatric disease or dementia, or other medical reasons that precluded physical training.

Patients were examined 1–2 days before surgery and at postoperative days 7, 30 and 90. After surgery, they were randomised to either progressive physical training (program A) or placebo activities (program B). The randomisation was stratified for hospital, sex, and colonic or rectal cancer (less than 15 cm from the anus) and performed in blocks of four or six (in random order). A person not otherwise involved in the project did it manually before the start of the study. The assignments were kept in numbered, sealed, opaque folders. The code was broken after last patient's last project-examination.

The investigators responsible for project examinations and the data keying were unaware of the randomisation assignment and patients were asked not to reveal information about this to the investigators. The character of the intervention made it impossible to blind the physiotherapists responsible for intervention and the patients. The patients were unaware of whether they belonged to the intervention group or the placebo group.

Intervention

Program A had a menu of progressively demanding exercises including mobilisation, strength training of upper and lower extremities and endurance training. Each intervention was anticipated to last 45–60 min. One-third of the time was to be used for mobilisation or aerobic training, 1/3 for strength training of the upper extremity and 1/3 for training the lower extremity. Mobilisation was primarily done during the immediate postoperative days. Walking or stair climbing trained aerobic capacity. Strength training was dynamic resistance training using free weights and aimed at a load of 50–80% of one repetition maximum (estimated by the physiotherapist).

Program B (the placebo intervention) had a menu of activities that were not expected to increase muscular strength or aerobic capacity. The activities included turning and positioning in bed, stretching and relaxing neck and shoulders, tightening and relaxation exercises, and hot wrappings and massage. Each intervention was planned to last 30–45 min.

From the first postoperative day until discharge (typically day 10) a physiotherapist intervened daily except on Sundays and days with study examinations. After discharge the patients had to continue exercises (program A or B) at home five times a week. The physiotherapist visited the patients in the home once a week to supervise the intervention.

Assessments

Height (without shoes) was measured to the nearest cm on a SECA height/weight measuring scale (SECA Meß-und Wiegetechnich, Hamburg, Germany).

Prior to measuring weight and bioimpedance the patient fasted for at least 2 h and voided within 30 min. Weight was measured to the nearest 0.1 kg on the SECA scale with the patient lightly dressed. The same scale was used every time. Calibration of the weighing scale was checked regularly and was stable. At admission, patients were asked about their body weight 3 months previously.

Bioimpedance was measured with a SFB3 bioimpedance meter (Impedimed Pty Ltd, Brisbane, Australia) at 50 Hz and 190 μA. Patients were supine on a nonconducting bed, arms and legs were slightly abducted and the arms parallel with, but not touching the body and the legs not touching each other. Two electrodes were placed on the skin dorsally on the right hand distally between II and III metacarpal bone and between the styloid processes of the ulna and the radius. Two electrodes were placed on the skin dorsally on the right foot, one distally between I and II metatarsal bone and one between the lateral and medial malleoli. The distal electrodes were drive electrodes and the proximal sense electrodes. The measurement was stored in the bioimpedance meter and transferred to a computer for further analysis. The calibration of the meter was checked monthly and was stable. LBM was calculated using the sex-based formulas developed by Heitmann, (1990) on a Danish population sample. FM was calculated by subtracting LBM from body weight.

Examinations also included assessments of physical performance with muscular strength, walking speed, physical performance test, timed chair stands, and a physical performance questionnaire. These results will be published separately.

Seven investigators did project-examinations. In all, 72% of follow-up examinations were made by the same investigator who made the first examinations. Day-to-day repeatability of tests was examined 3 months postoperatively where a total of 25 patients participated in project-examinations on two consecutive days.

Nutritional intake

Participants at one centre admitted from November 1999 to September 2000 were asked to register their nutritional intake. From postoperative day 1–7 (or until discharge if earlier than day 7) patients kept a food record. Measuring cups were used to facilitate recording and the staff helped when necessary.

Before discharge, a dietitian instructed the patient how to record food intake at home and prior to the follow-up examination 1 month postoperatively the patient assessed the intake on three consecutive days (Hessov, 1978). It was requested that one of the days was a Saturday or Sunday.

The food records were reviewed by the dietitian who used photographs and models to estimate intakes. The nutrient value of the food consumed was calculated from Danish food-composition tables (New food composition tables, 1996) by using the computer system Dankost 2000 (Dansk Catering Center, Herlev, Denmark).

Standard ward procedures

All patients were treated according to the usual regime at the hospitals that included preoperative bowel preparation, intraoperative antibiotics, and postoperative epidural analgesics and oral acetaminophen. At all centres were a well-described postoperative regime as published by Henriksen *et al* (2002a).

On the day of the operation and on the first postoperative day, drinks and fluids were allowed. Solid foods were introduced from the second day after which there were no food restrictions. The patients who recorded their nutritional intake were offered hospital food from the second postoperative day with a high protein content from a buffet served by the staff. Patients were encouraged to drink 450 ml of protein-energy fortified drinks from the first day after the operation until discharge. Nasogastric tubes were not allowed and no intravenous fluids were given routinely. Patients were expected to be out of bed for 4 h on postoperative day 1, 6 h on day 2 and at least 8 h from day 3. Compression stockings and low-molecular weight heparins were used to prevent thrombo-embolic complications.

After discharge the patients were recommended to continue with 450 ml of protein-rich drinks daily at their own expense until body weight was regained. We did not register whether this recommendation was met.

Complications

Complications were registered if noted in the patient's files.

Ethics

The study followed the Helsinki Declaration of 1983 and was approved by the local Ethical Committees of Aarhus and Northern Jutland (1998/4337). Patients gave informed, written consent prior to the scheduled operation.

Statistical methods

Data were analysed on an intention-to-treat basis using Stata (Stata7 version 7.0, College Station, TX, USA). The distribution of data was examined visually and statistically. If normally distributed, data were tested with students *t*-test for paired and unpaired data. If variance analysis showed differences in variance; *t*-test for data with different variance was used. If normality could not be assumed, Wilcoxon's test for paired and Mann–Whitney's for unpaired data were used. The probability level for statistical significance was 5% with no correction for multiple testing. Unfortunately, three patients did not perform the intervention they were assigned to (two assigned to program B performed A and one A performed B). However, withdrawing the above-mentioned three patients from the analysis of weight and body composition did not change any conclusions.

Results

Participants (Table 1 and Figure 1)

Of 240 eligible patients 147 were included. Of the patients, 23 refused to participate, in 46 cases there was no capacity for study examination, 13 patients were overlooked and 11 patients were missed for unknown reasons. Of the 147 included, 28 were excluded prior to randomisation due to disseminated cancer (16), lack of capacity for project examination (3), dropouts (3), no colorectal surgery (3), abdominal pain (1), comorbidity (1),

Table 1 Baseline values for randomised patients (mean (s.d.))

	A n = *60*	*B* n = *59*
Women/men	30/30	29/30
Age	72 (6.5)	72 (7.3)
Weight (kg)	72 (15.8)	74 (12.8)
Height (cm)	166 (8.4)	170 (9.5)
BMI (kg/m^2)	26 (4.8)	25.6 (3.4)
Lean body mass (kg)	48.5 (9.6) *n* = 43	51.5 (10.7) *n* = 44
Fat mass (kg)	22.3 (7.6) *n* = 43	22.6 (6.7) *n* = 44
Preoperative comorbidity (cardiovascular, lung, diabetes, musculo-skeletal)	38	40
Dukes = type		
A	5	9
B	23	18
C	21	16
D	1	3
Diverticulitis	4	3
Other, nonmalignant	6	10

an error as we thought she had disseminated cancer (1). This left 119 for randomisation and 60 were randomised to intervention A and 59 to B.

In group A 23 and in group B 11 patients left the study; 85 patients completed the full 3 months (Figure 1).

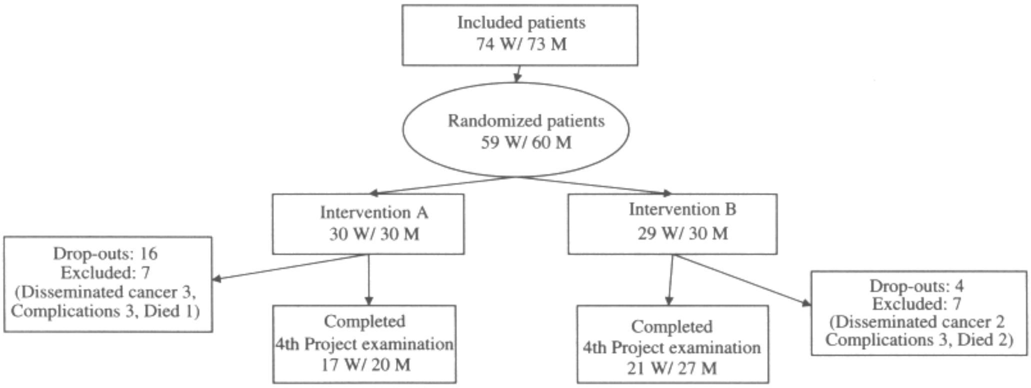

Figure 1 Patient flow. W = women, M = men. Dropouts left at own request. Excluded were excluded by investigators.

Table 2 Data from the per and postoperative course

	A n = *60*	*B* n = *59*
Abdomino-perineal resection	9	7
Low anterior resection	16	14
Hartmann's operation	10	7
Sigmoid resection	11	8
Left hemi-colectomy	3	2
Resection of transverse colon	0	1
Right hemi-colectomy	8	9
Local excision	0	1
Relieving stoma	0	1
Taking back Hartmann's operation	0	4
Other	3	5
Duration of operation (min)[a]	140 (110–170)	135 (110–163)
Blood loss—peroperatively (ml)[a]	400 (113–600) *n* = 56	300 (200–500) *n* = 58
Days in hospital after the operation[a]	10 (8–18) *n* = 60	10 (9–14) *n* = 59
Days in project after discharge[a]	78.5 (65–83) *n* = 44	82 (77–83) *n* = 51
Number of days performing home programme[b]	59 (45–68) *n* = 39	69 (59–79) *n* = 47
Number of home visits by the physiotherapist[c]	5 (2–7)	5 (3–7)
Minutes spent exercising at weekly supervisions after discharge[c]	45 (35 to 55)	40 (30 to 47)
Postoperative complications[d]		
Surgical	22	14
Infectious	18	23
Cardiovascular	9	6
Other	14	14

[a]Values are median (interquartile range).
[b]Difference between groups.
[c]Analysed as treated, three patients performed the opposite program from what they were assigned to.
[d]Surgical complications included anastomotic leak, wound dehiscence, ileus, and intraabdominal haemorrhage. Infectious complications were wound infection, bacteraemia, pneumonia, and bacteriuria. Cardiovascular complications were deep venous thrombosis, pulmonary embolia, and cardiac incompensation. Other complications included reoperation, delirium, and hernia.

Table 1 summarizes baseline characteristics for all 119 patients assigned to group A and B. The groups did not differ significantly in baseline values with the exception that the height of the patients in group A were significantly higher ($P=0.038$).

Per and postoperative course (Table 2)
The peroperative estimated blood loss was a median (interquartile range) of 400 (113–600) ml in group A and 300 (200–500) in B ($P=0.48$).

In all, 64 patients had postoperative complications and each patient had from one to eight complications. None of the postoperative complications were classified as adverse events with relation to intervention.

Training (Table 2)
In the hospital group A exercised a median (interquartile range) of 149 (92–210) min and group B 131 (72–177) min during 5 (4–7) and 6 (5–7) days, respectively. After discharge the proportion of training days was higher in group B with 69 (59–79) of 82 days (84%) compared to 59 (45–68) of 79 days (75%) in group A ($P=0.003$). Both groups received 5 (2–7) home visits and the training during these visits lasted 45 (35–55) (Group A) and 40 (30–47) min (Group B).

Body composition (Figure 2)
Preoperatively the patients in group A and B were similar in body composition (Table 1). Postoperative day 7 the weight had not changed in group A (−0.2 (1.7) kg), whereas group B had had a significant weight loss of −1.0 (2.4) kg ($P=0.005$); a nonsignificant difference of 0.8 (0.4) kg. Following discharge patients lost weight and at 1 month postoperatively the weight loss was approximately 3.4 kg and very similar in the two groups. There after weight was regained and 3 months postoperatively group A patients were −2.1 (4.4) kg below the preoperative level, whereas patients in group B were −0.5 (2.9) kg below; a difference in weight change of 1.6 (0.9) kg ($P=0.064$).

In the hospital, patients in group A gained 0.4 (2.1) kg of LBM compared to a loss of 0.7 (2.0) kg in group B. No difference between groups was seen after 1 month (−0.02 (0.5) kg) but after 3 months group B tended to have gained more LBM, though the difference of −0.7 (0.4) kg was not statistically significant ($P=0.13$).

FM was reduced at all follow-up examinations with a nonsignificant trend of greater loss of FM in group A.

For the groups taken together, the mean (s.d.) weight loss 1 month postoperatively was 3.4 (3.3) kg corresponding to 4.6%. Of the patients, 12 from group A and 15 from B had lost more than 4 kg after 1 month. At 3 months postoperatively, the weight was significantly reduced from preoperatively by a mean (s.d.) of 1.2 (3.7) kg ($P=0.003$) and FM reduced by 1.0 (2.8) kg ($P=0.005$). However, LBM was not significantly different from preoperative values with a change of −0.1 (1.8) kg ($P=0.54$).

Preoperative BMI was 24.9(4.2) kg/m^2 in women and 26.6 (3.4) kg/m^2 in men. Seven patients had a BMI below 20 kg/m^2.

The data on body weight 3 months preoperatively were too insufficient to be analysed with 53 of 119 possible values missing.

Nutritional intake (Figure 3)
All 32 patients included in the study in the nutritional registration period, 18 from A and 14 from B, registered their food intake during the hospital stay. After discharge 25 patients, 15 from A and 10 from B, registered. Four patients left the study and three patients had no registration after discharge due to lack of a clinical dietitian.

The nutritional intake rose during the postoperative days with a fall on day 5. The average energy and protein intake during postoperative day 1–7 was 72 (31) kJ/kg (A), and 64 (30) kJ/kg (B), and 0.73 (0.38) g/kg (A), and 0.60 (0.40) g/kg (B). Following discharge there was a further increase in energy and protein intake. At no time were differences between groups in energy or protein intake.

The subpopulation who registered their nutritional intake did not differ significantly with respect to age, BMI, LBM, FM, co-morbidity, length of hospital stay, or types of operation, but had fewer complications than the patients who did not register nutritional intake.

Discussion

Postoperative physical training had no significant effect on the differences between group A and B in changes in body weight, FM, energy, and protein intake. In group A, LBM measured by bioimpedance was preserved 7 days postoperatively, but no difference in LBM between groups was observed after 1 or 3 months.

The patients in this study had a normal BMI preoperatively—men 26.6 kg/m^2 and women 24.9 kg/m^2 with only seven persons with BMI below 20 kg/m^2 (Heitmann, 1991; Schroll *et al*, 1993). In previous studies on patients undergoing colorectal surgery (Jensen *et al*, 1998; Henriksen *et al*, 2002b), we have also found that the patients preoperatively generally had normal BMI's and only had small preoperative weight losses—approximately 1.7 kg (Jensen & Hessov, 1997b).

By postoperative day 30, the patients had lost a mean of 3.3 kg (1.2 kg LBM) corresponding to 4.6% of the preoperative weight. In previous studies of similar patients, we have found mean weight losses of 2–3 kg or around 5% (Jensen & Hessov, 1997b; Henriksen *et al*, 2002b) and other institutions have typically reported losses of 3–5 kg following uncomplicated abdominal surgery (Ulander *et al*, 1998) However, 27 of 81 (33%) patients had weight losses exceeding 4 kg. We did not find that mean preoperative weight or LBM was regained after

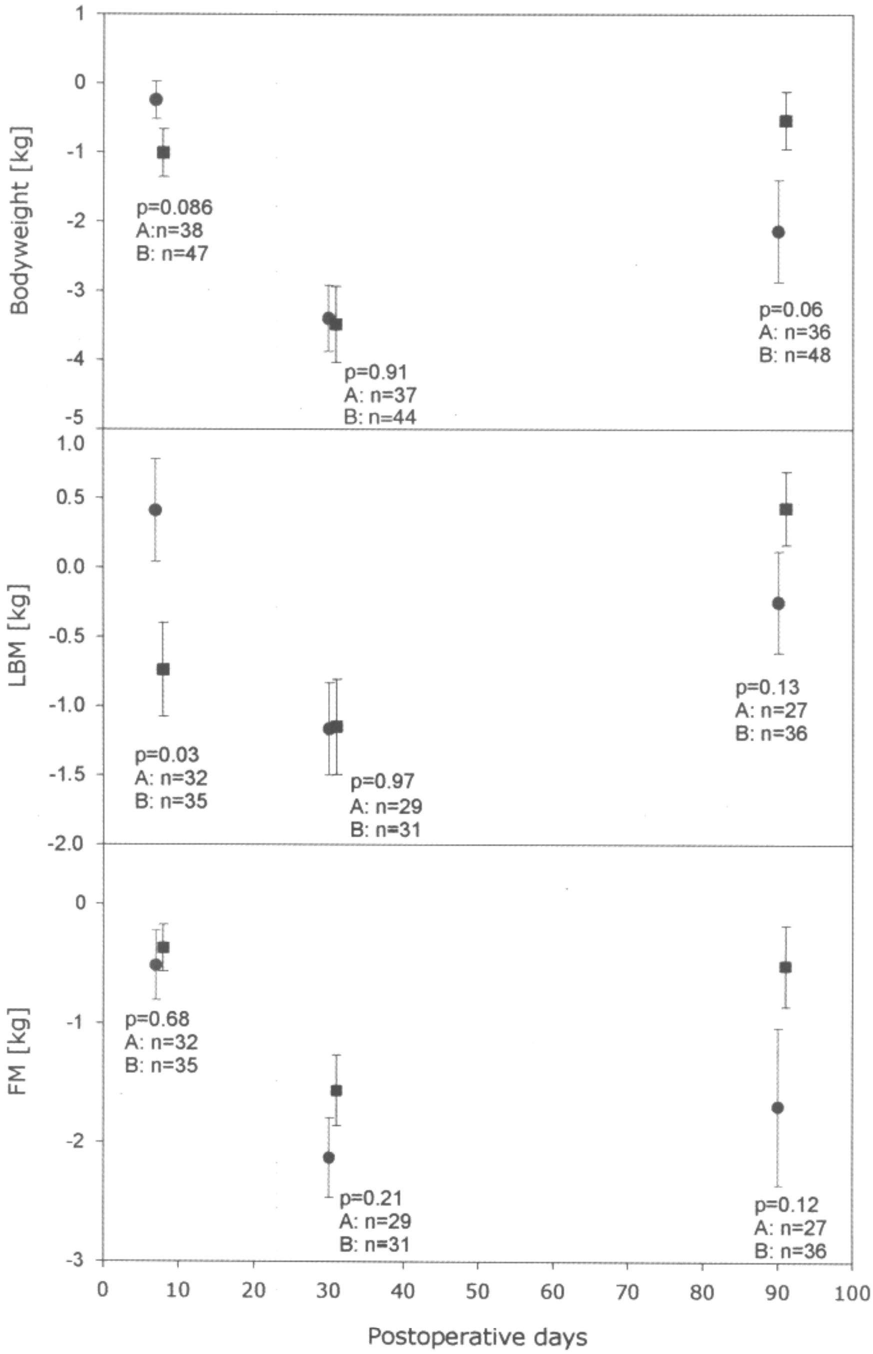

Figure 2 Changes from preoperative in body weight, lean body mass (LBM), and fat mass (FM). Values are mean (s.e.m.). ● Group A, ■ Group B.

3 months, in fact the weight was significantly reduced by 1.2 kg and any preoperative weight loss has to be added to that.

The recommended daily energy intake based on official Danish recommendations was an estimated energy intake of 110–130 kJ/kg and estimated protein intake of 1.3–1.8 g/kg during hospitalisation (Pedersen & Ovesen, 1999). After discharge, we recommended a protein intake of 1.5 g/kg (Jensen & Hessov, 1997b).

The energy intake of 49–90 kJ/kg during the first postoperative week and protein intake of 0.45–0.84 g/kg did not meet any recommendations. Recommended energy intake was met 1 month postoperatively, but the

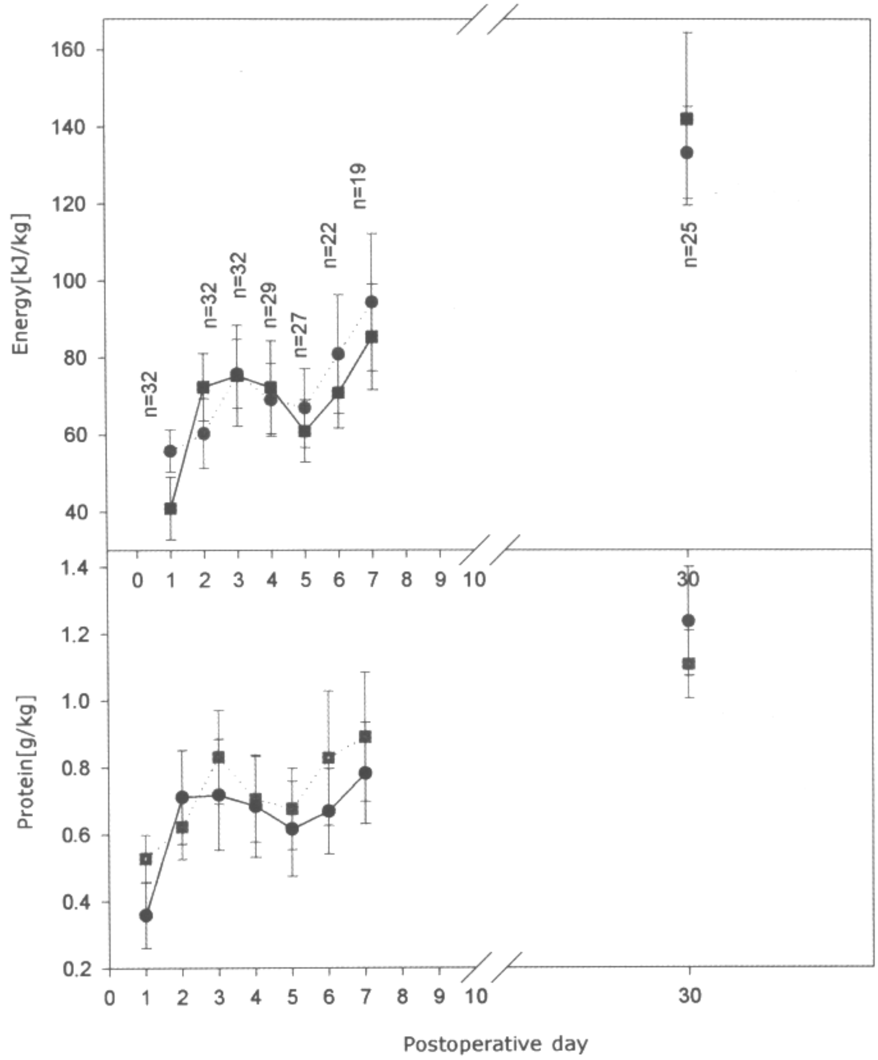

Figure 3 Energy- and protein-intake in the postoperative period. Values are mean (s.e.m.). ● Group A, ■ Group B.

protein intake was still lower than recommended. This might explain why the LBM was yet not regained as seen in a previous study from our department (Jensen & Hessov, 1997b). As actual energy expenditure was not assessed we do not know whether nutritional energy needs were met.

The intakes were also lower than previously observed in our ward with protein-fortified drinks supplemented during hospital stay (Henriksen *et al*, 2002b) and after discharge (Jensen & Hessov, 1997b). In an observational study on the energy intake following colorectal surgery on 75 consecutive patients, it was found that energy intake was insufficient to meet estimated basal energy expenditure, regardless of the intake being oral, parenteral, or a combination (Bermon *et al*, 1997; Ulander *et al*, 1998). Our study confirmed this observation.

The mean energy and protein intakes fell on day 5 and we have speculated if the five patients that had been discharged might explain the decline. As more patients were discharged on day 6 and 7 the mean energy and protein intakes rose, however, and we therefore doubt that discharge before day 7 can bias the results.

We anticipated that physical training would lead to an increased food intake and a preservation of LBM and thereby body weight. However, the patients that trained and those doing placebo activities had very similar intakes and changes in body composition. This is in accordance with some (Butterworth *et al*, 1993; Blundell & King, 2000), but not all (Bermon *et al*, 1997) studies. In a randomised trial on 32 sedentary elderly women with a mean BMI around 26 kg/m^2, the effect of 12 weeks of moderate exercise was studied. No significant changes in energy and protein intake were found between those who did calisthenics and those who trained. Body composition was not different between groups, either (Butterworth *et al*, 1993). Blundell and King (2000) concluded in a review that exercise does not stimulate energy intake; the review addressed, however, primarily exercise and weight reduction. Titchenal, (1988) concluded in a review of the literature on exercise and food intake and concluded that energy intake is generally increased or unchanged in response to exercise, the increase being in highly trained athletes or lean individuals. Obese or untrained individuals often do not change food intake by exercise.

The effect of exercise and nutritional supplementation on body weight and energy intake was studied in 100 octogenarians, who were cross-randomised to 10 weeks of strength training and oral supplements (+360 kcal and 15 g of protein per day). The participants were normal weight. No significant effect of exercise on body weight was observed, however, the participants who received the nutritional supplements gained 0.8–1.0% of body weight compared to those who received a placebo supplement. It was observed that exercise augmented the total energy intake, particularly in the group receiving supplements. (Fiatarone *et al*, 1994). Somewhat in contrast to this, Bermon *et al* (1997) randomised 20 malnourished elderly randomised to 3 weeks of aerobic training or to no training and found that those who trained had significant increases in body weight, although there were no significant differences in energy and protein intake.

The assessments of body composition are affected by body hydration as bioimpedance measurements are sensitive to abduction of limbs, recent consumption of food and fluids, recent exercise, changes in hydration status and fluid distribution and changes in serum elctrolytes and hematocrite. Although measurement conditions were standardised as described, many patients were preoperatively undergoing bowel preparation and in the immediate postoperative days fluid distribution were altered. It is unknown whether fluid distribution have returned to normal on postoperative day 7. How theses possible fluid shifts affected the measurements are unknown.

As depicted in Figure 2 there was a trend towards preservation of body weight and LBM in the intervention group 1 week postoperatively and conversely 3 months postoperatively where group B had a tendency towards smaller weight loss. The nutritional intake was not significantly different between groups and any explanation would only be speculative. One speculation is a possible effect of the placebo program as compliance was better after discharge in group B than in group A.

In all, 23 patients randomised to program A (active training) left the study compared to 11 in group B (placebo activities). The patients who left the study after randomisation were older, less tall, but did not differ in weight or proportion of LBM or FM. As we observed no difference between A and B in body composition after 1 or 3 months we do not suspect selection bias.

This study confirmed that elective colorectal surgery is followed by a reduced intake of protein and energy, a loss of body mass with loss of both lean tissue mass and FM; body mass was not regained 3 months after the operation.

Protein intakes in the first postoperative week and 1 month postoperatively did not meet recommendations. Energy intake was also lower than recommended during the first week but met recommendations 1 month postoperatively. In our patients, who were well nourished before operation physical training did not increase nutritional intake.

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