A Randomized Controlled Trial of Weight Reduction as a Treatment for Breast Cancer-related Lymphedema

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BACKGROUND. Obesity is considered a risk factor for the development of breast cancer-related lymphedema of the arm and as a poor prognostic factor in response to lymphedema treatment. The objective of this study was to examine weight reduction as a treatment for breast cancer-related lymphedema.

METHODS. Twenty-one women with breast cancer-related lymphedema were randomized either to receive dietary advice for weight reduction or to receive a booklet on general healthy eating. They were monitored for 12 weeks.

RESULTS. The primary outcome measure was arm volume at 12 weeks. The results indicated a significant reduction in swollen arm volume at the end of the 12-week period ($P = .003$) in the intervention weight-reduction group. There was a significant reduction in body weight ($P = .02$) and body mass index ($P = .016$) in the weight-reduction group at the end of the 12-week study period.

CONCLUSIONS. Weight loss achieved by dietary advice to reduce energy intake can reduce breast cancer-related lymphedema significantly. ***Cancer*** **2007;110: 1868–74.** © *2007 American Cancer Society.*

KEYWORDS: diet, weight reduction, breast cancer, lymphedema, intervention.

Breast cancer-related lymphedema (BCRL) is a common problem after breast cancer treatment. Studies suggest that BCRL may occur in 20% to 42% of all patients with breast cancer.[1,2] It can affect function of the arm and the patient's psychological adjustment and quality of life.

Risk factors for the development of lymphedema include the extent of axillary lymph node dissection and adjuvant radiotherapy to the regional lymph nodes. Other predisposing risk factors for the development of BCRL after treatment reported in the literature include age, infection, pre-existing cardiovascular conditions, and the surgical technique used, although reports are conflicting.[3]

Many studies have suggested that obesity or being overweight may predispose women to developing lymphedema after treatment for breast cancer.[4–8] Obesity is a risk factor for postmenopausal breast cancer and, thus, is present in a high proportion of this group of patients.

Some early studies indicated that the degree of lymphedema was correlated positively with the level of obesity.[7,8] More recently, this was confirmed by a study examining the factors that affected the risk of arm edema in 251 women who had undergone surgical treatment for breast cancer. Three years posttreatment, the risk of developing lymphedema was related to hospital skin puncture of the limb, mastectomy rather than wide local excision, and a body mass index (BMI) >26 kg/m^2.[9]

It is unclear how obesity may influence the development of lymphedema, but proposed mechanisms have included an increased

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risk of postoperative complications, including infection, reduced muscle-pumping efficiency within loose tissues, additional fat deposition that contributes to arm volume, and the separation of deep lymphatic channels by additional subcutaneous fat.[9–12] It also has been suggested that excess body weight may limit the effectiveness of elastic compression.[5]

Some practice guidelines in the literature now recommend the maintenance of ideal body weight in patients with lymphedema to assist in their management, although this is regarded as a common-sense approach rather than being supported by published evidence.[13] A previous study undertaken at the Royal Marsden National Health Service (NHS) Foundation Trust examined the potential benefit of changing diet in women with lymphedema after treatment for breast cancer. The dietary interventions used were a weight-reducing diet and an isocaloric, low-fat diet. The study suggested that weight reduction, irrespective of the type of dietary intervention, may help to reduce the volume of the swollen arm. Even relatively small amounts of weight reduction were reflected in a reduction in arm volume.[14] The objective of the current study was to evaluate the effectiveness of weight reduction on changes in excess arm volume in overweight women with BCRL.

MATERIALS AND METHODS

Participants and Study Design

Women with arm lymphedema secondary to treatment for breast cancer were recruited from the Lymphedema Clinic at the Royal Marsden Hospital and through the Lymphedema Support Network (a national patient organization). Participants underwent conventional treatment for lymphedema, including the use of compression hosiery that was fitted and monitored by trained lymphedema nurses. Inclusion criteria were 1) a swollen arm of $\geq$15% excess volume compared with the unaffected arm, 2) remission from cancer, 3) no chemotherapy or radiotherapy in the previous 12 months, and 4) a BMI $\geq$25 kg/m^2. Participants may or may not have been receiving hormone treatment.

The study was approved by the Clinical Committee for Research and the Ethics Committee of the Royal Marsden Hospital. Signed consent was received from all participants who entered the study.

On recruitment to the study and prior to randomization to the control and dietary-intervention groups, the participants completed a 7-day dietary diary to assess their habitual dietary intake. The diary used was based on household measures for assessment of portion size with additional photographs to help determine the portion sizes that were eaten.[15] The validity of this method was measured by other investigators and demonstrated accuracy comparable to that demonstrated by weighed dietary intakes without the inconvenience of performing a weighed food intake.[16] The initial dietary assessment was used to help plan individual dietary advice for the participant.

Interventions

Participants were randomized to the following groups, taking into account excess limb volume and concurrent drug treatment.

Control group

No specific dietary intervention advice was given. Patients were given the Royal Marsden NHS Trust Patient Information Series Booklet No. 31 on healthy eating, which provides advice on how to maintain a healthy diet.

Weight-reduction group

Individualized dietary advice was given on a weight-reduction diet with the objective of reducing body weight to the acceptable average weight for height. Diet plans were designed to produce an energy deficit of 1000 kcal (4184 kJ) per day from habitual intake derived from the prerandomization diet record, and no participant was recommended a daily intake $<$1000 kcal (4184 kJ).

The majority of participants were advised to reduce their dietary intake to between 1000 and 1200 kcal (4184–5020 kJ) per day. Advice was based around the participant's usual meal pattern, and the reduction of energy intake was achieved by reducing foods that contained fat and refined carbohydrate. A system of exchanges was used to enable consumption of a variety of foods that contained for protein, fat, and starchy carbohydrate.

Dietary advice and intervention was given by the same registered dietitian (C.S.) for the duration of the study. Exercise and activity were not monitored in the study, and no specific advice was given to participants.

Outcome Measures

Arm volume

Manual measurements of arm circumference were taken from both arms from the wrist upward at 4-cm intervals. The volume of each 4-cm segment was calculated using the following equation[17]:

$$\frac{\text{Circumference}^2}{\pi} = \text{Volume}$$

The results were expressed as the percentage of excess arm volume compared with the volume in the

unaffected arm. All measurements were taken by 1 investigator. To reduce bias, measurements were recorded independently of the measurements taken at the previous visit, and actual arm volumes were calculated at the end of the study.

Anthropometric measures

Height was measured using a stadiometer, and weight was measured using Seca digital scales. In addition, skinfold thickness (a means of estimating total body fat) was determined at 4 sites (triceps, biceps, subscapular, and suprailiac) using Harpenden skinfold calipers.[18] Measurements of skinfold thickness always were taken on the unaffected arm. Measurements of skinfold thickness were taken by the same investigator (C.S.) who was trained and practiced in the technique.

Dietary intake

Dietary intake data were collected prior to randomization and at 6 weeks and 12 weeks using 7-day dietary diaries, which included photographs of small, medium, and large portion sizes. This method was chosen because it provides a greater degree of accuracy than records that rely entirely on estimation of food portions without the inconvenience of a weighed food record, and it has been demonstrated that the method has good correlation with weighed food intakes.[15] Diet diaries were analyzed using the Dietplan5 computer program (Forestfield Software Ltd.), which is based on *McCance and Widdowson's Composition of Foods*.[19] Weights were allocated to foods using the known weights of the photographed foods in the diet records together with the Ministry of Agriculture, Forestry, and Fisheries guide to food portion sizes, as appropriate.[20] All dietary records were coded by 1 dietitian and were entered into the computer program as 1 week, and the figures were averaged to provide for a daily reported intake of energy and nutrients supplying energy. The data presented were collected from the dietary diary prerandomization and at Week 12.

Patients were followed up for 12 weeks, because this was period during which maximal weight reduction was observed in the previous study. Dietary compliance was assessed by interview and 24-hour recall at the Week-4 and Week-8 visits. The same dietitian took the recall, and participants in the intervention group were given additional advice to encourage dietary compliance.

Statistical Analysis

The study was designed with the intention to recruit 50 patients, including 25 patients in each group. This was based on the assumptions that dietary intervention would be of benefit to 50% of the patients in the study group and that 10% of patients in the control group could benefit. The sample size required was determined by using the Medical Research Council sample size calculation program. A 2-sided test was used with 90% power at the 5% significance level.

Comparisons were made between treatment groups to examine whether there were any differences in anthropometric measurements and excess limb volume prior to dietary intervention. Nonparametric statistical tests were used to analyze the data, because it was not distributed normally. The Mann-Whitney *U* test was used to detect differences between the main outcome measures for the 2 groups, and correlations were calculated using Spearman rank correlation coefficient. All statistical analyses were done on an intention to treat basis.

Computer-generated randomization was undertaken by the data managers at the Institute of Cancer Research, Sutton, Surrey. Prior to randomization into the control or dietary intervention group, the participants were stratified according the volume of their arm and whether they were taking any hormone medication for breast cancer. Each group was randomized independently to ensure 1) that no group had a disproportionate number of large limbs, which may have been expected to respond differently to treatment; and 2) that medications, which may have influenced body weight, were taken into account. Limbs were stratified into the following 2 groups: 1) Group A, swollen limb from 15% to 50% larger than the unaffected arm; and 2) Group B, swollen limb >50% larger than the unaffected arm.

RESULTS

Twenty-four participants were recruited to the study, and 21 women completed the 12-week dietary-intervention period. The 3 women who failed to complete the 12-week period of the study were excluded for the following reasons: Two women were unable to commit to the demands of the study, and 1 woman developed recurrent breast cancer.

Fewer participants than intended were recruited into the study. The protocol required patients to have a swollen arm that was >15% larger than their unaffected arm on recruitment, and few new patients fell into this category. We believed that this was caused in part by a change in the treatment of breast cancer in which axillary dissection, rather than axillary clearance, became the preferred treatment, and the dose of radiotherapy to the whole of the axilla was reduced. Both of these strategies were intro-

TABLE 1
Characteristics of Treatment Groups Prior to Dietary Intervention

Characteristic	Total	Control group	Weight-reduction group	*P*
No. of patients (%), N = 21	21	10 (48)	11 (52)	
Median age, y	60	59	60	863
Height, cm*	162 ± 7	165 ± 5	160 ± 7	.152
Weight, kg*	83.9 ± 16.7	81.3 ± 13.9	86.3 ± 19.3	.705
BMI, kg/m^2*	32 ± 6	30 ± 5	33 ± 6	.152
Skinfold thickness, total mm*	78.8 ± 20	80.6 ± 18	76.9 ± 22	.705
Swollen arm volume, % excess volume*	24 ± 10	25 ± 8	24 ± 12	.387
Tamoxifen/provera	15/21	8/11	7/10	.918

BMI indicates body mass index.
* Values shown are the mean ± standard deviation.

TABLE 2
Excess Arm Volume Expressed as a Percentage of Normal Arm Volume in the Control and Weight-reduction Group at Day 1 and Week 12

	Mean ± SD		
Variable*	Control group (N = 10)	Weight-reduction group (N = 11)	*P*
Excess arm volume, %			
D 1	25 ± 8	24 ± 12	
Wk 12	25 ± 7	15 ± 10	
Difference	0 ± 4	10 ± 9	.003†
Excess volume, mL			
D 1	819 ± 260	802 ± 323	
Wk 12	808 ± 275	452 ± 232	
Difference	11 ± 114	349 ± 325	

SD indicates standard deviation.
* Excess arm volume = swollen limb (mL) − unaffected limb (mL) on Day 1.
† Statistical comparison of change in excess arm volume in the control group versus the weight-reduction group (Mann-Whitney *U* test.)

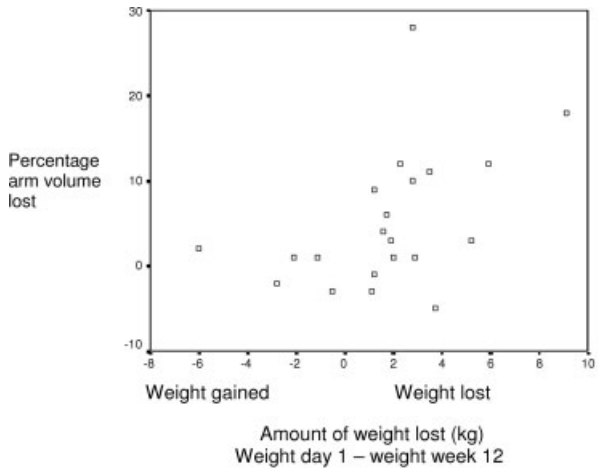

FIGURE 1. Correlation of changes in arm volume and weight change for women with lymphedema over the 12-week period (N = 21). The Spearman rank correlation coefficient was 0.513. The *P* value was statistically significant at .017. This figure correlates changes in arm volume, shown as the percentage excess compared with the normal arm, with weight changes over the 12-week study period.

duced to reduce the number of patients who developed lymphedema.

Characteristics of the control group and the weight-reduction group are shown in Table 1. There were no significant differences between the 2 groups prior to randomization with respect to weight, BMI, skinfold thickness, excess arm volume, or hormone medication. Reported dietary intake, as determined from the 7-day dietary records, was lower in the control group prior to dietary intervention.

There was a significant difference in excess arm volume between the control group and the weight-reduction group at the end of the 12-week study period ($P = .003$). There was no change in the excess arm volume of the control group during the study period (Table 2), whereas in the weight-reduction group, the mean excess arm volume reduced from 24% ± 12% to 15% ± 10%. There was a significant correlation between changes in arm volume and weight loss with a correlation coefficient of 0.513 ($P = .017$) (Fig. 1). The weight-reduction group lost some volume from their unaffected arm (mean loss, 121 mL), although this was less than the mean 350 mL lost from the swollen arm (Table 3).

After the 12-week period of dietary intervention, the control group demonstrated no overall weight change, whereas the weight-reduction group lost a mean of 3.3 ± 2.6 kg ($P = .02$) with an associated fall in BMI of 1.3 ± 1.1 kg/m^2 ($P = .016$). There was a numerical reduction in skinfold thickness, although this was not statistically significant (Table 4).

After the 12-week intervention period, there was a significant reduction in the reported intake of

TABLE 3
Changes in Arm Measurements Between Day 1 and the End of Week 12

	Mean ± SD			
	Control group		Weight-reduction goup	
Variable	Unaffected, mL	Swollen, mL	Unaffected, mL	Swollen, mL
D 1	3220 ± 541	4039 ± 692	3412 ± 911	4214 ± 1054
Wk 12	3235 ± 561	4028 ± 699	3291 ± 830	3864 ± 831
Difference	+15	−11	−121	−350

SD indicates standard deviation.

TABLE 4
Anthropometric Measurements in the Control and Weight-reduction Groups at Day 1 and at the End of Week 12

	Mean ± SD		
Variable	Control group (N = 10)	Weight-reduction group (N = 11)	*P*
Weight, kg			
D 1	81.3 ± 13.9	86.3 ± 19.3	
Wk 12	81.6 ± 15.6	83 ± 16.8	
Difference*	0 ± 2.97	3.3 ± 2.6	.020†
BMI, kg/m^2			
D 1	30 ± 5	33.3 ± 6.1	
Wk 12	30 ± 5.7	32 ± 5.7	
Difference*	0.0 ± 2.97	1.3 ± 1.1	.016†
Skinfold thickness, total mm			
D 1	76.9 ± 17.7	80.6 ± 22	
Wk 12	74.4 ± 16.3	75.6 ± 18.7	
Difference*	2.5 ± 9.2	5.0 ± 5.6	.426

SD indicates standard deviation; BMI, body mass index.
* Differences are from D 1 to Wk 12.
† Changes from D 1 to Wk 12 in the control group, compared with changes in the weight-reduction group, differed significantly (Mann-Whitney *U* test).

energy, fat, and carbohydrate in the weight-reduction group compared with the control group (Table 5). There was no difference in the intake of protein between the 2 groups.

DISCUSSION

Despite small numbers, the results from this study clearly demonstrate a significant reduction in lymphedema arm volume after weight reduction compared directly with the control group, which remained weight stable with no change in arm volume. There also was a significant correlation between weight loss and reduction in arm volume, suggesting that lymphedema may continue to improve with additional weight loss. These results

TABLE 5
Reported Daily Intakes of Energy and Energy-supplying Nutrients in the Control and Intervention Groups and Intragroup Differences Between Day 1 and Week 12

	Mean ± SD		
Variable	Control group (N = 10)	Weight-reduction group (N = 11)	*P*
Energy, kcal			
D 1	1446 ± 386	1865 ± 422	
Wk 2	1474 ± 296	1452 ± 367	
Difference	28 ± 223	−412 ± 232	.002*
Fat, g			
D 1	60 ± 23	75 ± 26	
Wk 12	61 ± 15	52 ± 24	
Difference	1 ± 22	−23 ± 16	.008*
Protein, g			
D 1	64 ± 13	70 ± 17	
Wk 12	66 ± 12	66 ± 13	
Difference	2 ± 6	−4 ± 11	.251
Carbohydrate, g			
D 1	163 ± 52	232 ± 45	
Wk 12	158 ± 41	175 ± 52	
Difference	6 ± 21	−48 ± 40	.000*

SD indicates standard deviation.
* Changes from D 1 to Wk 12 in the control group, compared with changes in the weight-reduction group, differed significantly (Mann-Whitney *U* test).

complement those from our previous study, which also demonstrated a correlation between weight loss and arm volume irrespective of the dietary method for weight loss.[14]

The weight loss achieved in this study was comparable to that achieved in other studies that aimed to reduce weight through dietary advice[21] and was similar to that achieved in a previous study undertaken at the Royal Marsden NHS Foundation Trust in which a weight-reduction group lost a mean of 3.2 kg at 12 weeks and 4 kg at 24 weeks. A comparable group of obese postmenopausal women with breast cancer in the Netherlands had a median weight loss of 6 kg after 1 year of advice and monitoring by dietitians.[22] The data for skinfold thickness did not reflect the changes in body weight or BMI, and this is most likely a reflection of the insensitive nature and difficulty with performing this measurement, particularly in obese individuals. Reported energy intake fell in the weight-reduction group, although only to a level comparable to the reported energy intake of the control group. Although 24-hour dietary recall and 7-day diet diaries are useful in helping to develop a dietary plan for participants, the accuracy of these records has been questioned, and underreporting of intake is common, especially in participants who have a high BMI.[23] The control group in

the current study appears to have been more likely to report initial low energy intake than the intervention group. We have no explanation for this. In an ideal situation a daily energy deficit of 400 kilocalories per day over a period of 12 weeks would be expected to lead to a weight loss of 4.8 kg. In practice, the ideal rate rarely is achieved, but the weight loss observed in the current study was comparable to that reported in other studies.[22]

It is necessary to consider how much of the excess arm volume in lymphedema may contribute to additional weight in these patients. Prior to dietary intervention, the participants had an excess limb volume ranging from 369 mL to 1781 mL in individual women. This may have represented up to approximately 1.7 kg excess weight, depending on the composition of the excess volume. This figure is based on the assumption that the tissue has a density of approximately 1.0×10^3 kg/m^3. The exact composition of lymphedematous tissue is unknown, but body fat has a fairly constant density of approximately 0.9×10^3 kg/m^3, which means that every liter would weigh 0.9 kg.[24] The weight, therefore, is unlikely to contribute a significant amount to the degree of overweight and obesity observed in our patients at the beginning of the study.

When calculating changes in arm volume, for the purpose of the current study, the unaffected arm volume on Day 1 always was used as a control to allow accurate comparisons between the 2 groups. The unaffected arm also was reduced in volume as participants lost weight, and this would have resulted in figures that were not comparable between the 2 groups, because the measure against which arm volume was calculated also was changing.

At the end of the 12-week study, the weight-reduction group had lost a greater volume from the swollen arm than from the unaffected arm. On average, the weight-reduction group lost $7\% \pm 6\%$ from their swollen arm compared with $3\% \pm 6\%$ from their normal arm. This is a noteworthy point, and it is possible that weight reduction in lymphedema had an additional, previously unknown effect, allowing additional lymph drainage from the whole arm. If the effect of weight reduction had been caused only by a loss of adipose tissue, then the volume lost from each arm would have been expected to be proportionate to the volume lost in the other arm. Another possible explanation for the effect of diet on the lymphedematous arm is that the composition of the diet, an energy-restricted diet that emphasized the reduction of dietary fat, was having a direct effect on the composition of the limb. Our previous study, in which a low fat diet was given to a similar group of patients, failed to demonstrate that altering the composition of the diet alone, without weight loss, could affect the volume of the swollen limb.[14]

The results from a study by Stanton et al. in 2001 indicated that the pathophysiology of BCRL is more complex than simple axillary lymphatic obstruction. Lymphoscintigraphy employing radioactively labeled immunoglobulin G was used to examine the swollen and nonswollen areas in the arms of women who had BCRL.[25] The conclusions generated by the study were that axillary surgery and radiotherapy created increased resistance to the actively contractile lymphatic collectors of the arm. The distribution of swelling in the arm ultimately depends on the eventual pump failure of the weakest vessels and, when local vessels have not yet failed, these areas are spared the development of edema. It would be interesting to use this technique before and after a period of weight reduction to monitor any sites of change in lymphatic flow that my be facilitated by weight loss.

Weight reduction also may have influenced the action of compression hosiery. In a study monitoring the effectiveness of elastic compression in 120 patients with BCRL, it was demonstrated weight gain was the only significant, independent negative factor that influenced response to elastic compression.[5] Reduction of weight and arm volume may help the action of elastic compression when it is fitted correctly. It is important to monitor women during a period of weight reduction and to refit compression hosiery accordingly.

The participants who were recruited into the current weight-reduction study were heavier and had a lesser degree of lymphedema compared with the participants in a previous dietary-intervention study.[14] The less severe lymphedema may have been caused in part by the better overall management of lymphedema within the health service than was provided previously. Recruitment to this study was difficult, because a number of participants did not fit the study criteria, in that they had a swollen arm that was $<15\%$ larger than the unaffected arm. It appears that, for women to have a degree of lymphedema with an arm volume 15% larger than the normal arm, they had to be heavier and to have a higher mean BMI of 32 kg/m^2 than in the previous Royal Marsden intervention study, in which the mean BMI was 27 kg/m^2.[14] The intervention group had a higher BMI than the control group, although the difference was not significant, and the excess arm volume at the beginning of the study was comparable between the 2 groups. The weight-reduction group had a significant change in their lymphedema for a relatively small weight loss, indicating that lymphedema of

this type in overweight women is amenable to dietary intervention through weight reduction. The effect appears to be more than just losing adipose tissue from beneath the skin.

From the results of the current study, we recommend that, for women with lymphedema related to treatment for breast cancer who are overweight, weight reduction should be considered as part of the overall management of their lymphedema. Some current guidelines recommend the maintenance of ideal body weight, although they do not address the benefits of weight reduction.[13] Weight reduction should be integrated into the lymphedema management plan, and all members of the multidisciplinary team should be aware that the patient is aiming to lose weight. Regular reassessment of compression hosiery should be performed to ensure that, as arm volume decreases, appropriate hosiery is fitted to maintain the maximum effect possible.

REFERENCES

1. Mansel RE, Fallowfield L, Kissin M, et al. Randomised multicenter trial of sentinel lymph node biopsy versus standard axillary treatment in operable breast cancer: the ALMANAC trial. *J Natl Cancer Inst*. 2006;98:599–609.
2. Armer J, Fu MR, Wainstock JM, et al. Lymphedema following breast cancer treatment including sentinel lymph node biopsy. *Lymphology*. 2004;37:73–91.
3. Moorrell RM, Halyard MY, Schild SE, Ali MS, Gunderson LL, Pockaj BA. Breast cancer-related lymphoedema. *Mayo Clin Proc*. 2005;80:1480–1484.
4. Arrault M, Vignes S. Risk factors for developing upper limb lymphoedema after breast cancer treatment. *Bull Cancer*. 2006;93:1001–1006.
5. Bertelli G, Venturini M, Forno G, Macchiavello F, Dini D. An analysis of prognostic factors in response to conservative treatment of postmastectomy lymphedema. *Surg Gynecol Obstet*. 1992;175:455–460.
6. Say CC, Donegan W. A biostatistical evaluation of complications from mastectomy. *Surg Gynecol Obstet*. 1974;138: 370–376.
7. Falardeau M, Poljicak M, Aboujaoude M, et al. Lymphedema after treatment of cancer of the breast. *Prog Lymphol*. 1988;XI:289–292.
8. Segerstrom K, Bjerle P, Graffman S, Nystrom A. Factors that influence the incidence of brachial oedema after treatment of breast cancer. *Scand J Plast Reconstr Hand Surg*. 1992; 26:223–227.
9. Clark B, Sitzia J, Harlow W. Incidence and risk of arm oedema following treatment for breast cancer: a three-year follow up study. *QJM*. 2005;98:343–348.
10. Brorson H. Adipose tissue in lymphedema: the ignorance of adipose tissue in lymphedema. *Lymphology*. 2004;37: 175–177.
11. Clodius L. The causes of the swollen arm: obesity and lymphoedema. In: Clodius L, editor. Lymphoedema. Stuttgart, Germany: Thieme; 1977;151–152.
12. Britton RC, Nelson PA. Causes and treatment of postmastectomy lymphedema of the arm. *JAMA*. 1962;180: 95–102.
13. Harris SR, Hugi MR, Ollivotto IA, Levine M; Steering Committee for Clinical Practice Guidelines for the Care and Treatment of Breast Cancer. Clinical practice guidelines for the care and treatment of breast cancer: 11. Lymphedema. *CMAJ*. 2001;164:191–199.
14. Shaw C, Mortimer P, Judd PA. A randomised controlled trial comparing a low fat diet with a weight reduction diet in breast cancer related lymphedema. *Cancer*. 2007;109:1949–1956.
15. Thorogood M, Roe L, McPherson K, Mann J. Dietary intake and plasma lipid levels: lessons from a study of the diet of health conscious groups. *BMJ*. 1990;300:1297–1301.
16. Edington J, Thorogood M, Geekie M, Ball M, Mann J. Assessment of nutritional intake using dietary records with estimated weights. *J Hum Nutr Diet*. 1989;2:407–414.
17. Taylor R, Jayasinghe UW, Koelmeyer L, Ung O, Boyages J. Reliability and validity of arm volume measurements for assessment of lymphedema. *Phys Ther*. 2006;86:205–214.
18. Durnin JV, Womersley J. Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. *Br J Nutr*. 1974;32:77–97.
19. McCance RA, Widdowson EM. McCance and Widdowson's Composition of Foods. London, UK: Royal Society of Chemistry; 2002.
20. Crawley H. Household Food Portions. London, UK: Ministry of Agriculture, Forestry, and Fisheries, Her Majesty' Stationery Office; 1988.
21. Ashley JM, St Jeor S, Schrage JP, et al. Weight control in the physician's office. *Arch Intern Med*. 2001;161:1599–1604.
22. de Waard F, Ramlau R, Mulders Y, De Vries T, van Waveren S. A feasibility study on weight reduction in obese postmenopausal breast cancer patients. *Eur J Cancer Prev*. 1993;2:233–238.
23. Goldberg GR, Black AE, Jebb SA, et al. Critical evaluation of energy intake data using fundamental principles of energy physiology. 1. Derivation of cut-off limits to identify under recording. *Eur J Clin Nutr*. 1991;45:569–581.
24. Martin AD, Daniel MZ, Drinkwater DT, Clarys JP. Adipose tissue density, estimated adipose lipid fraction and whole body adiposity in male cadavers. *Int J Obes Relat Metab Disord*. 1994;18:79–83.
25. Stanton AWB, Svensson WE, Mellor RH, Peters AM, Levick JR, Mortimer PS. Differences in lymph drainage between swollen and non-swollen regions in arms with breast cancer related lymphoedema. *Clin Sci*. 2001;101:131–140.