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ORIGINAL ARTICLE

Evaluation of a web-based weight loss intervention in overweight cancer survivors aged 50 years and younger

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Summary

Purpose

Half of adult cancer survivors under age 50 years are obese. Excess body weight is associated with cancer recurrence, and effective weight loss interventions for younger cancer survivors are needed. Commercially available, online weight loss programmes are readily accessible, but few have been studied in this population. This study employed a single-arm, pre-post intervention (baseline-6 month/baseline-12 month comparisons) to preliminarily explore feasibility, efficacy and safety of an online, commercially available weight loss programme in breast (n = 30) and testicular (n = 16) cancer survivors under age 50 years.

Methods

The intervention included three daily components: exercise, nutritional/behavioural modification strategies and health lessons. Intention-to-treat and completers analyses were conducted. Feasibility was measured by participation (number of participants enrolled/number screened), retention (number of participants attending 6/12 month study visit/number of enrolled) and self-reported adherence rates (average of mean percent adherence to each of the three intervention components). Efficacy was assessed by changes in initial weight (percent weight loss). Safety was assessed by adverse events.

Results

The mean participation rate was 42%. The retention rate was 59% at 6 and 49% at 12 months. The adherence rate for all participants (completers/dropouts/lost-to-follow-up) was 50.1% at 6 and 44% at 12 months. Completers reported adherence rates of 68% at 12 months. Study participants lost 5.3% body weight at 12 months; completers lost 9%. Only three unexpected adverse events (unrelated to the intervention) were reported.

Conclusion

Clinically significant weight loss was observed, although retention rates were low. Findings generally support preliminary feasibility, efficacy and safety of this online weight loss programme, and future randomized control trials should be explored.

Keywords: Weight loss, internet, cancer survivor.

Introduction

Survival rates for cancer rose over the past decade (1). However, cancer survivors face health problems secondary to disease and treatment. Compared with age-matched peers, cancer survivors are at increased risk for mortality and are more likely to be affected by cardiovascular and metabolic co-morbidities, including obesity, type-2 diabetes and dyslipidaemia (2,3). Although these negative health effects may be the result of the disease and its treatments, lifestyle behaviours, specifically poor diet and lack of physical activity, may also play a role

(4–7). Thus, weight control in cancer survivors represents an important public health initiative.

Cancer is often diagnosed at older ages (above age 60 years), and most weight control studies focus on these older age categories (1). In young adult cancer survivors (defined as cancer diagnosis between the ages of 18 and 39 years (8,9)), the consequences of treatment-related co-morbidities, such as obesity, are of particular concern. Young adult cancer survivors and cancer survivors diagnosed under the age of 50 years are exposed to many more years of increased risk for co-morbidities compared with older survivors, and they have seen little or no improvement in excess mortality rates for decades (8,9). Additionally, over half of adult US cancer survivors under age 50 years are overweight or obese (10,11), and less than 40% meet recommended physical activity guidelines (4,12–14). Weight loss and physical activity programmes would benefit cancer survivors (5,15,16), and younger cancer survivors have expressed interest in these programmes (17); however, interventions with demonstrated efficacy are lacking.

Most weight loss interventions conducted in cancer survivors have employed in person or telephone counselling to promote changes in diet and physical activity (18–23). Younger adult cancer survivors prefer remotely delivered interventions with social support (24,25). Thus, web-based weight loss interventions have particular appeal to young cancer survivors. Approximately 90% of young adults have home Internet (26), the average age of non-cancer participants in successful web-based interventions is 40 years (27) and web-based programmes can be as effective as in-person programmes (27).

A number of online, web-based programmes demonstrate clinically significant weight loss of 5% in persons with obesity (27–35). Many of these online programmes, particularly commercially available programmes (32–35), are self-directed and completed at home with little supervision and variable participant–provider contact. However, to our knowledge, few, if any, of these online, commercially available programmes have been evaluated in younger cancer survivors (under age 50 years) with excess body weight.

We conducted a single-arm pilot study of a commercially available, Internet-based weight loss intervention called Lean Eating by Precision Nutrition Coaching, in young adult cancer survivors (29). The goal of this pilot was to evaluate the preliminary feasibility, efficacy and safety of this online programme. This study targeted testicular and breast cancer survivors, as these cancers account for approximately 20% of young adult cancers, and survivors treated for these tumors are particularly vulnerable to post-treatment metabolic consequences (15,16). We chose to evaluate Precision Nutrition Coaching because of the following: (i) this programme supports the American Cancer Society (ACS) guidelines on Nutrition and Physical Activity for Cancer Survivors (36); and (ii) it incorporates principles of behaviour change from social cognitive theory that were used in prior successful web-based interventions (37), including daily logging of exercise regimens/health lessons, tailored feedback from an online coach, goal setting and peer support from discussion boards (30,31). We hypothesized that this commercially available, online programme would demonstrate preliminary feasibility (on the basis of participation, dropout and adherence rates) and efficacy (as measured by changes in weight and body composition) and would safely support weight loss in cancer survivors (on the basis of number and type of adverse events reported).

Methods

Participants and inclusion/exclusion criteria

Participants were patients from the Abramson Cancer Center of the Hospital of the University of Pennsylvania. Patients were eligible for study participation if they were between the ages of 18 and 50 years at the time of enrollment, had a prior diagnosis of testis (men) and breast (women) cancer, were cleared by their oncologist for participation in a weight loss intervention, were at least 6 months from diagnosis, cancer-free and finished with all oncologic surgery, radiation and chemotherapy. Breast cancer survivors currently taking hormonal therapy or trastuzumab or who had a diagnosis of lymphedema were eligible. Clinical information verifying preliminary eligibility was collected from electronic medical charts. Trained research staff then approached clinically eligible participants and determined final eligibility either over the phone or during routine clinic visits. Additional inclusion criteria included no contraindications to vigorous dieting or exercise, a status of overweight (body mass index [BMI] >25 kg m^{-2}), regular access to the Internet and a computer and willingness to purchase basic fitness equipment or join a fitness facility. Study participants also had to agree to pay $10/month for the programme (discounted from standard cost of $99/month), with the chance to be reimbursed at the end of the study period on the basis of self-report adherence rates (see outcome assessment) and attendance at all study visits.

Study design for screening, recruitment and study measures

Clinically eligible participants were recruited 3 months prior to the start of the weight loss intervention by trained

research staff. Recruitment prioritized participants with upcoming clinic appointments to minimize participant burden, which created a convenience sample for this study. At the time of eligibility screening (either in person during a clinic visit or over the phone), persons interested in the intervention were given the option to enroll in the study immediately (by signing informed consent and scheduling their baseline visit) or to receive follow-up information via email before enrolling. This approach resulted in screening more individuals than needed and more interested participants than expected, because participants often decided to enroll closer to the start of the intervention. The original target sample size was a total of 30 participants (15 men and 15 women), on the basis of a sample size calculation using standard deviations from literature and predicting a weight loss of 5% (80% power, alpha level 0.05) for each gender (31,38). We ended up enrolling all interested, screened eligible participants (n = 46; men = 16 and women = 30). For screened participants who chose not to enroll (n = 64), reasons for declining enrollment were recorded (Figure 1). All study participants started the intervention at the same time. All study procedures were approved by the Institutional Review Board, and all participants provided informed consent.

This 1-year pilot had three recorded study visits: baseline, 6 months into the study and 12 months. At each study visit, clinical anthropometric measures were taken by the same study staff, and participants completed a demographic and risk behaviour questionnaire that included questions from the National Health Information Survey (39) and the College Alumni Health survey (40) related to diet and exercise, such as 'during the past year, how many city blocks or their equivalent did you walk on an average day?' Exit interviews were conducted with enrolled participants who withdrew from the study and agreed to the interview (6 of 13 dropouts). Those lost-to-follow-up were not reached (n = 11) for an exit interview and did not have anthropometric measures beyond the baseline visit.

To quantify and assess safety, biweekly emails were sent to enrolled participants asking them to self-report any changes in upper or lower body symptoms. Every 3 months, breast cancer survivors completed the Norman Lymphedema survey (41), given that lymphedema is a potential co-morbidity of breast cancer (42). Breast cancer

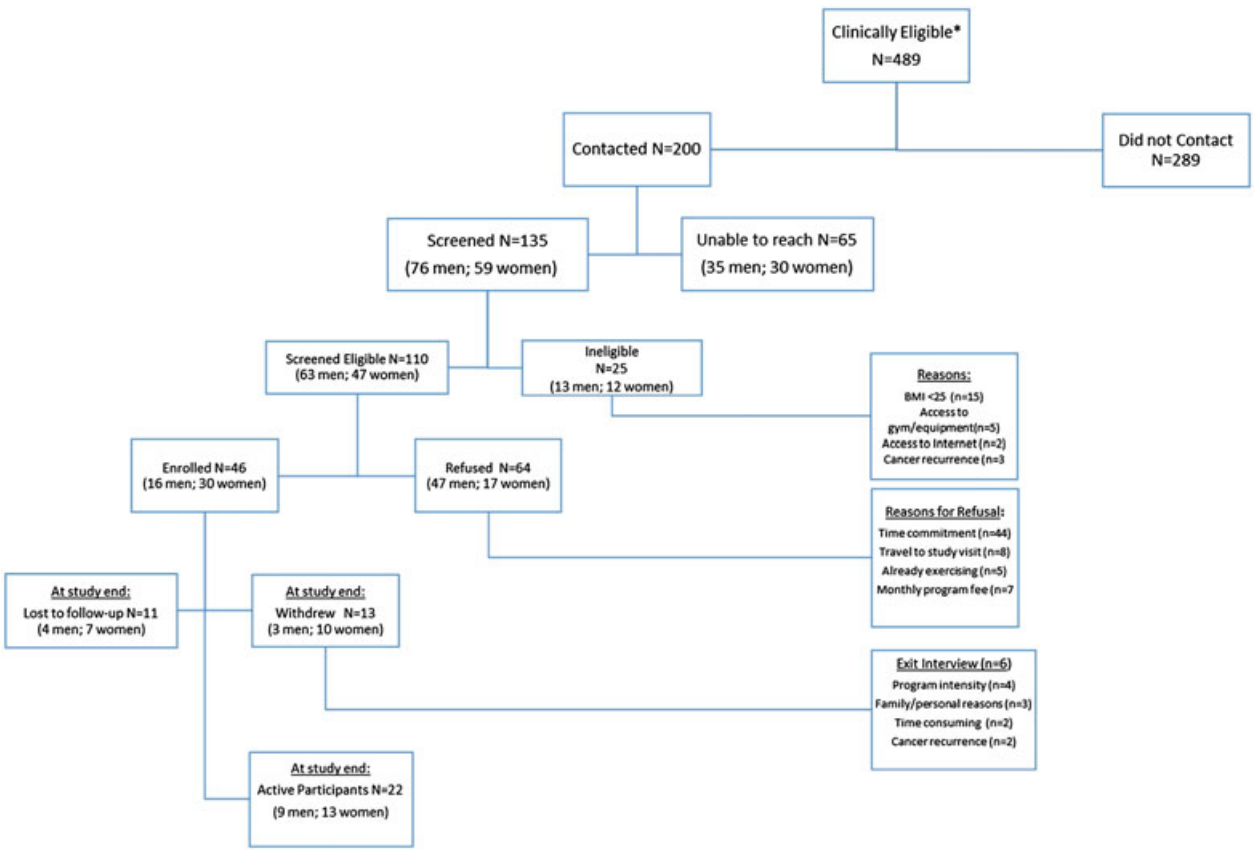

Figure 1 Study recruitment and retention.

survivors also were required to participate in a lymphedema risk reduction educational webinar, on the basis of guidelines from the National Lymphedema Network, prior to the intervention.

Web-based intervention

The commercially available online programme developed by Precision Nutrition Coaching, Lean Eating, is designed as a 1-year weight loss and healthy eating intervention for adults in the general population (29). The Precision Nutrition Coaching Program is administered via an online website and focuses on achieving weight loss through the combined efforts of three main components (as described next). These components were derived from determinants of social cognitive theory, specifically meant to improve participant self-efficacy, self-regulation, outcome expectancy and social support (29,37). For example, to improve self-efficacy and self-regulation, participants were asked to login to a password-protected, personalized webpage daily to both view and record whether they completed a daily assignment, daily nutritional habit and a daily exercise regimen. Daily automated email reminders to login were sent to every participant. To enhance social support, each participant was assigned an online, same-gender coach to assist with questions about the programme using email, phone or Internet-based communication (i.e. Skype). All female and all male participants in this study had the same coach. The coach sent monthly group emails, as well as individual emails, as needed (coaches generally reach out if participants have not logged in or communicated with the coach in over 2 weeks). Participants also have access to peer discussion boards for social support.

Exercise component

Daily exercises were prescribed on the website and could be completed at home or in a gym. The exercise programmes varied slightly by gender, but each gender-specific programme followed the ACS physical activity guidelines for cancer survivors, i.e. at least 150 min of exercise per week, including at least two strength training days per week (36). Specifically, women participated in 3 d of weight training (approximately 35 min), 2 d of cardiovascular or interval training(approximately 30 min), one active recovery day that could include walking, stretching, yoga and one rest day. Separate from the standard programme, breast cancer survivors had the option, in consultation with their coach, to substitute the original online exercises (if they were too difficult) with modified exercises that took into account musculoskeletal changes that may have occurred during cancer treatment. These modifications were made in consultation with an exercise physiologist and physical therapist who specialize in treatment of breast cancer survivors (42). Eleven percent of breast cancer survivors reported using the modifications at least once during the programme. As part of the standard programme, men participated in 4 d of weight training (approximately 35 min), 1 d of interval training (approximately 30 min), one active recovery day and one rest day per week. Regardless of gender, weight training exercises started with basic pulling and pushing movements with dumbbells and elastic bands, focussing on form and core body work, then progressed over the 12-month programme to vary the weight, sets and repetitions of learned exercises. Exercises were described in a printable document with pictures, as well as demonstrated by same-gender fitness models in online videos located on the website. Exercise regimens changed every 4–6 weeks on the webpage, and exercise movements and programmes became more challenging (i.e. more weight, more complex movement and less repetitions) over the course of the programme. Participants were asked to self-report and record daily whether they had completed the exercise regimen in order to improve self-efficacy and self-regulation (32).

Nutritional/behavioural modification component

The healthy habit component was designed to gradually introduce dietary and healthy lifestyle changes in order to improve self-regulation and self-efficacy (29). This component followed the ACS nutritional guidelines for cancer survivors to achieve a dietary pattern high in vegetables, fruits and whole grains (36). Instead of prescribing a specific meal plan or promoting caloric restriction, every 2 weeks, participants were given a new healthy habit to practice. Men and women participated in the same healthy habits. Example healthy habits included the following: eating four to five servings of fruit/vegetables, drinking eight glasses of water, eating healthy carbohydrates, like whole grains, and getting 7–8 h of sleep per day. Each time participants were notified of a new habit on the webpage, they were asked to maintain the habits from the previous weeks, but they were only expected to self-report daily whether they were following the most current healthy habit.

Daily lesson component

Participants were asked to read lessons (approximately 10–15 min) each day and record or self-report whether they completed the lesson daily. Daily lessons corresponded with the healthy habits and explained to participants how to follow a habit and why that habit is

important. Lessons also included approaches to incorporating healthy habits in daily life, goal setting and assignments designed to improve self-efficacy, self-regulation and outcome expectancy (29), including keeping a food diary for 2 weeks, determining personal and social barriers to diet and exercise and how to overcome them, how to grocery shop, how to eat healthy and exercise while traveling, listing three positive outcomes (can be physical, social or emotional) from the previous week's programme and so on.

Outcome assessments

The main outcomes in this study were as follows: (i) participation rates, retention and dropout rates and adherence rates (self-report data) to evaluate feasibility; (ii) clinically measured changes in body composition (percent weight loss, BMI, body fat percentage and waist-to-hip ratio) at baseline and 6 months and baseline and 12 months into the intervention to evaluate efficacy; and (iii) evaluation of safety (number and type of adverse events). Participation rates were determined by the proportion of screened eligible subjects that agreed to the intervention. Retention rates were determined by the proportion of participants who did attend the 6- or 12-month study visits divided by total enrolled. Dropout rates were determined by the proportion of participants who did not attend the 6- or 12-month study visit divided by the total enrolled. Dropout rates included those lost-to-follow-up and those who voluntarily withdrew from the study (dropouts). Reasons for declining enrollment and the top four reasons for study withdraw from exit interviews were also quantified and reported. Overall self-report adherence rates were determined quantitatively by averaging the mean self-report percent completion, over the course of 6 and 12 months, to each of the three daily intervention components (lessons, nutrition/lifestyle and exercise). Participants were asked to login to the website daily and check 'yes or no' to record whether they completed each component; percent completion was calculated by averaging the number of yes responses compared with the sum of daily workouts/lessons/habits administered at the date of the last study visit. For those who dropped out or were lost-to-follow-up at both the 6- and 12-month study visit, the self-report adherence rate was assumed to be zero. Participants lost-to-follow-up generally had not logged in to the intervention website for over 120 d prior to the end of the programme. Thus, it is likely they were not participating in the intervention. Those who reported a $>$80% adherence rate to the intervention and completed all study visits were reimbursed the cost of the programme ($120).

Height was measured at baseline using a stadiometer, and body weight was measured using a digital scale (Seca 876 scale, Seca Corporation, Hamburg Germany). Girth measurements of the waist and hip were measured using a non-elastic measuring tape, where the waist was measured at the top of the iliac crest and the hips at the widest point of the hip. Body fat measurements (seven-site skinfold test) were recorded using calipers (Lange caliper Model EQ0014921). Age and gender were considered in skinfold calculations (43,44). Skinfold measurements are cost-effective, highly correlated with other measurements of body fat, including ultrasound, particularly when conducted by a trained professional (45,46), and have been used in cancer populations (47). All anthropometric measures were taken by the same, trained member of the research team at all study visits. Anthropometric measures were taken twice, and the average of the two measurements was recorded.

A study Safety Officer evaluated the biweekly safety emails and spoke with participants who reported an upper or lower body symptom. The Safety Officer then determined the following: (i) whether the event was unexpected or expected; (ii) whether the event was possibly, probably or unrelated to the study; and (iii) the seriousness of the event (Grades 1–4, with 1 being mild and 4 being the most severe) according to common terminology criteria for adverse events (48). All symptoms that were unexpected, probably related to the study, or Grade 3 or higher are reported here.

Statistical analysis

This study employed a pre-post, single group design. Descriptive statistics are reported as means and standard deviations for continuous variables and as proportions for categorical variables. The first half of the programme (months 0–6) was focussed on weight loss and healthy eating, whereas weight maintenance was the focus of the second half (6–12 months); therefore, we evaluated outcomes during the 6- and 12-month visits separately. There is a lack of consensus on how to report and analyse data from a single-arm study; thus, we conducted both a completer's analysis (to compare clinical changes in anthropometric outcomes within participants who completed both the baseline and 6- or 12-month visits) and an intention-to-treat analysis for each outcome (assuming a value of zero for adherence and zero for weight change for those participants who were lost-to-follow-up or exited the study prior to a study visit) (44). Changes in outcome variables from baseline to 6 months and baseline to 12 months were analysed using a paired-samples *t*-test. An independent sample *t*-test

was performed to compare differences in demographic factors between men and women. Fisher's exact test was used to compare proportions by gender. Statistical tests were two-sided at an alpha of 0.05. All data were analysed using STATA (version 11).

Results

Table 1 presents the baseline demographic variables of study participants. The mean age of participants was 39 (standard deviation $\pm$ 6.2) years. The average age of men was significantly lower than women, age 36 years compared with age 42 years (p value = 0.001). Study participants were mostly Caucasian, highly educated, married and living with adults and/or children. The mean time from diagnosis was 48 $\pm$ 27 months. Half of the women in the study were post-menopausal, with menopause attributed to cancer treatment (surgery, chemo and/or radiation).

Feasibility

Recruitment/participation

A total of 489 clinically eligible individuals were identified from medical record data (eligible on the basis of age, diagnosis date, oncologist clearance, completion of treatment etc). We contacted 200 of the initial 489 individuals by phone or in clinic and reached 68% of those individuals (n = 135) (Figure 1). We stopped contacting participants once it was clear that recruitment goals were met (n = 289 not contacted). A total of 110 participants were screened eligible (on the basis of BMI, computer/Internet access, access to fitness equipment and willingness to pay for the programme). A total of 25 participants were ineligible at baseline for the following reasons: BMI $<$ 25 (n = 15), no Internet (n = 2), not willing to join gym (n = 5) and cancer recurrence (n = 3). Forty-two percent (46/110) of screened eligible participants enrolled (participation rates by gender: 64% women and

Table 1 Baseline characteristics of study participants by gender[a]

	All (n = 46)	Women (n = 30)	Men (n = 16)	p value[b]
Age	39 (6.2)	41(5.2)	37(6.1)	0.001
Race (%)				
Caucasian	98	96	100	0.48
Time since diagnosis (months)[a]	48 (27)	48 (24)	47 (32)	0.95
Current menopausal status (%)				
Pre-menopausal		30		
Perimenopausal		20		
Post-menopausal		50		
Education (%)				0.82
High School	4	0	13	
College	37	40	31	
Graduate school	37	33	44	
Vocational	2	4	0	
Some College	20	23	12	
Marital status (%)				0.76
Marriage-like relationship	74	73	75	
Single	24	23	25	
Divorced	2	3	0	
Living situation (%)				0.54
Alone	13	17	6	
With adults	23	20	31	
With adults and children	64	64	63	
Physical Activity[a]				
Stairs climbed per day	35 (12)	35 (11)	35 (13)	0.95
Blocks walked per day	8 (2.1)	8.5 (3.1)	7.5 (2.0)	0.85
Weight[a] (kg)	90.5 (15)	85.4 (14)	99.9 (13)	0.001
Body mass index[a] (kg m^{-2})	31.8 (4.4)	31.3 (4.9)	32 (3.6)	0.62
Waist-to-hip ratio[a] (cm)	0.90 (0.13)	0.85 (0.14)	0.94 (0.04)	0.01
Body fat percentage[a]	30.2 (4.6)	32.4 (4.6)	27.5 (4.0)	0.003

[a]Mean of continuous variables (standard deviations) presented; percentages of categorical variables presented.
[b]Baseline characteristics between men and women compared using t-tests for mean values and Fisher's exact test for proportions.

25% men). A total of 64 screened eligible participants declined to participate (and had more than one reason for refusing) related to the following: time commitment/work and/or family (n = 44); already participating in an exercise programme (n = 5); concern about extra travel for visits (n = 8); and unwillingness to pay the monthly programme fee (n = 7).

Retention

At the end of 6 months, 59% of the study population remained in the study (n = 27); 41% voluntarily withdrew (n = 11) or were lost-to-follow-up (n = 8). At 12 months, 49% of the study population remained (n = 22); two more participants voluntarily withdrew, and three more participants were lost-to-follow-up. At 12 months, the retention rate for men was 56.6% and for women was 43.3%. Of the 13 participants who withdrew from the study, six completed exit interviews. Most mentioned that the programme was 'intense', requiring much time and attention (n = 4), and half mentioned personal and family reasons for having to withdraw from the study (Figure 1).

Adherence

The overall self-report adherence rate (including completers, dropouts and lost-to-follow-up) was 50.1% at 6 months and 44% at 12 months. The self-report adherence rate was 70% and 68% for those who remained in the study at 6 (n = 27) and 12 months (n = 22), respectively. For men who remained in the study (n = 9), the 12-month self-report adherence rate was 71%; for women (n = 13), it was 69%. The average self-report adherence rate for each intervention component at 12 months for all study participants – exercise (45%), healthy habit (40%) and lessons (49%) – was similar and not significantly different (p value = 0.09), suggesting participants were not more inclined to complete one weight loss component over another.

Efficacy: changes in weight

In the intention-to-treat analyses, participants lost on average 4.8 + 3.2 kg or 5.3% of body weight at the end of the intervention (12 months) (Table 2). Participants also had significant decrease in body fat percentage and BMI at 12 months. Percent weight loss was significantly associated with programme adherence rates when analysed as continuous variables at 12 months (correlation = 0.80, p value = 0.04). In the completer's analysis, participants who attended the 6-month study visit and remained in the intervention (n = 27) lost an average of 5.5 $\pm$ 4.2 kg or 6.5% of initial body weight (Table 3). At 12 months, 22 participants remained and lost an average of 8.1 $\pm$ 7.6 kg or 9% of initial body weight (Table 3). Participants who completed the intervention also had significant decreases in body fat percentage and BMI at 6 and 12 months (Table 3). In the intention-to-treat and completers analyses, patterns were similar by gender, although men had greater improvements in body composition than women (Tables 2 and 3).

Safety

Three unexpected adverse events were reported that were deemed unrelated to the intervention: deep vein

Table 2 Intention-to-treat analysis: body composition from baseline, 6 months and 12 months for all study participants (n = 46), men (n = 16) and women (n = 30) using paired t-test

	Baseline (mean, SD)	6 Months (mean, SD)	6-Month difference (mean, SD)	p value	% change	12 Months (mean, SD)	12-Month difference (mean, SD)	p value	% change
All									
Weight (kg)	90.5, 15	87.3, 15.2	−3.2, 2.0	<0.001	−3.5	85.7, 14.1	−4.8, 3.2	<0.001	−5.3
BMI (kg m^{-2})	31.8, 4.4	30.6, 4.6	−1.2, 1.1	<0.001	−3.8	30.3, 4.8	−1.5, 2.1	0.0001	−4.7
Waist-to-hip	0.90, 0.13	0.87, 0.12	−0.03, 0.11	0.12	−3.3	0.84, 0.10	−0.06, 0.2	0.09	−6.7
Body fat %	30.2, 4.6	29.7, 6.0	0.5, 0.2	0.25	−1.7	28.8, 4.8	−1.4, 0.8	0.04	−4.6
Men									
Weight (kg)	99.9, 12.6	95.7, 13.4	−4.2, 3.5	0.003	−4.2	94.1, 13.3	−5.8, 3.4	0.004	−5.8
BMI (kg m^{-3})	30.8, 4.2	29.8, 3.4	−1.0, 0.8	0.002	−3.2	29.3, 3.6	−1.5, 1.0	0.002	−4.9
Waist-to-hip	0.94, 0.04	0.93, 0.05	−0.01, 0.02	0.07	−1.1	0.91, 0.03	−0.03, 0.003	0.05	−3.2
Body fat %	27.5, 4.7	25.7, 4.5	−1.8, 0.10	0.003	−6.5	24.6, 4.9	−2.9, 1.1	0.003	−10.5
Women									
Weight (kg)	85.4, 14.0	82.7, 14.1	−2.7, 2.5	0.0006	−3.2	81.2, 13.1	−4.2, 2.1	0.006	−4.9
BMI (kg m^{-2})	31.2, 3.3	31.0, 5.2	−0.2, 0.5	0.001	−0.6	30.8, 3.8	−0.4, 0.8	0.005	−1.3
Waist-to-hip	0.85, 0.14	0.81, 0.16	−0.04, 0.2	0.21	−4.7	0.78, 0.11	−0.07, 0.2	0.12	−8.2
Body fat %	32.4, 4.6	31.7, 4.3	−0.7, 1.3	0.14	−2.2	30.5, 4.1	−1.9, 0.9	0.002	−5.9

Table 3 Completers analysis: body composition from baseline, 6 months, 12 months for all active participants (n = 27 at 6 months; n = 22 at 12 months), men (n = 9 at 6 and 12 months) and women (n = 18 at 6 months; n = 13 at 12 months) using paired t-test

	Baseline (mean, SD)	6 Month (mean, SD)	6-Month difference (mean, SD)	p value	% change	12 Months (mean, SD)	12-Month difference (mean, SD)	p value	% change
All									
Weight (kg)	89.9, 12.7	84.4, 15.8	−5.5, 4.2	<0.001	−6.5	81.8, 11.9	−8.1, 7.6	0.0002	−9.0
BMI (kg m^{-2})	31.0, 3.2	29.8, 4.8	−1.96, 1.5	<0.001	−6.0	28.5, 3.6	−2.5, 2.5	0.0001	−8.1
Waist-to-hip	0.87, 0.15	0.82, 0.12	−0.06, 0.16	0.07	−6.8	0.79, 0.10	−0.08, 0.16	0.06	−9.2
Body fat %	30.0, 4.9	27.7, 5.1	−2.4, 2.0	<0.001	−8.0	26.5, 4.1	−3.5, 1.7	0.03	−11.7
Men									
Weight (kg)	97.2, 12.7	91.7, 13.6	−7.5, 3.9	0.0004	−7.7	88.2, 11.6	−9.1, 7.1	0.005	−9.3
BMI (kg m^{-3})	30.8, 4.2	29.3, 4.0	−2.8, 1.3	0.0002	−8.7	27.9, 3.2	−2.9, 2.2	0.004	−9.4
Waist-to-hip	0.94, 0.03	0.90, 0.04	−0.02, 0.002	0.001	−4.3	0.89, 0.03	−0.05, 0.04	0.01	−5.3
Body fat %	26.6, 4.7	24.4, 5.3	−3.2, 1.7	0.0004	−11.6	22.2, 4.9	−4.4, 1.9	0.002	−16.5
Women									
Weight (kg)	83.3, 9.4	80.8, 15.9	−4.5, 4.1	0.0002	−5.3	77.5, 10.3	−5.8, 7.9	0.02	−7.0
BMI (kg m^{-2})	31.2, 3.3	30.0, 5.3	−1.6, 1.5	0.0004	−5.0	29.0, 3.8	−2.2, 2.8	0.01	−7.1
Waist-to-hip	0.84, 0.13	0.79, 0.13	−0.07, 0.19	0.15	−7.1	0.76, 0.11	−0.08, 0.19	0.22	−9.5
Body fat %	30.0, 4.3	29.4, 4.3	−1.9, 2.1	0.001	−6.1	28.8, 4.1	−1.2, 2.0	0.03	−4.0

thrombosis (related to a clotting disorder), syncope (due to medication changes) and pneumonthorax (identified during a routine clinic visit). Two participants reported expected musculoskeletal symptoms associated with prolonged exercise: shoulder discomfort and back pain. Both symptoms resolved after resting for 1 week. One of three women with a pre-existing lymphedema diagnosis prior to the study start experienced a recurrence probably related to the intervention and was referred to physical therapy. No incident lymphedema cases were identified.

Discussion

To our knowledge, this was one of the first studies to evaluate a commercially available online weight loss programme in young adult cancer survivors under the age of 50 years. Preliminary findings suggest this programme is generally feasible, safe and can result in clinically significant weight loss, but study retention is a major concern. Feasibility was assessed through participation, retention and adherence rates. Participation rates for previous web-based physical activity interventions, which include adults under the age of 45 years, range from 16% to 90% (31,37,49,50). Our participation rate in general (42%) and for women (64%) is comparable. The participation rate for men, although in the range of other web-based physical activity interventions (37), was lower (25%). According to a literature review of web-based physical activity interventions, the dropout rate in this pilot (51%) was within range of other physical activity interventions (7–69%), although our rate was higher than the average (27%) (37). The adherence rates reported in this study are based on self-reported completion of daily lessons, habits and exercises over the course of the 1-year programme. Self-report adherence rates in this study (44% at 12 months) were lower than other web-based intervention adherence rates (66.6%) (37,51,52) for the full study population, but were similar for active participants who completed the intervention (68%). General declines in adherence over the course of a 1-year intervention are expected (31,37,51,52). However, it is difficult to make comparisons between this intervention and those in literature. Existing online interventions have focussed primarily on physical activity only (31,37,49,50), and they include study populations composed of healthy, overweight, diabetic, sedentary and mostly all female participants (31). Further, adherence rates have not been consistently defined across these studies, and the duration of existing online interventions has varied from 8 weeks to 12 months (31).

Higher dropout rates in this pilot potentially could be explained by the length of the intervention, the daily commitment to recording diet and physical activity on the website and the nature of the exercise programme (most interventions focus on walking and less on weight training) (31,37). Studies show that participant interest in a weight loss programme often declines over time, particularly if the programme relies on logging features, such as signing into a website or recording physical activity (50). This can affect not only programme adherence but also study attrition. Additionally, at the 6-month study visit, 40.7% of the active study participants in this pilot mentioned they were engaging in exercise activities,

like yoga and swimming, in addition to the prescribed exercise programme, suggesting that an exercise programme that allows for multiple exercise options may appeal to younger survivors and could help with dropout rates.

Although the web-based nature of this intervention was meant to allow for more flexibility in time management (in order to address family/work commitments, a well-cited barrier to participation in weight loss interventions (20,53)), younger adult cancer survivors who withdrew from this study reported time commitment and family/personal reasons as barriers to continued participation. Plus, retention rates were generally lower in this pilot compared with other web-based programmes conducted in overweight populations. Thus, it is possible that unique psychosocial needs of younger adult cancer survivors could be impacting participation, adherence and attrition in this weight loss intervention (17,54). Younger adult cancer survivors are less likely to engage in exercise and are more likely to be overweight; they are also more likely to report emotional distress related to balancing health and home responsibilities compared with older survivors and age-matched peers (53,55). Thus, it is possible that the 'after effects' of cancer treatments and surgeries (including physical limitations and hormonal therapies post treatment) present not only physical but also emotional challenges for young cancer survivors, making it difficult for them to cope with the behaviour changes needed for weight loss (52,56–58). Given that respondents on the exit interview in this pilot mentioned 'program intensity and having to do too much' as a reason for study withdraw, interventions that assess a participant's coping skills and emotional readiness for weight loss, and that provide physical activity/nutritional information tailored to an individual's emotional, social and physical needs, could help young cancer survivors become more active (49,59,60). However, this hypothesis would need to be tested in future studies.

In both the intention-to-treat and completer's analyses, clinically significant weight loss (~5% change in body weight) was achieved by the end of the intervention. In the intention-to-treat analysis, testicular cancer survivors were able to change their designation from obese (BMI $>$ 30) to overweight (BMI $<$ 30). In the completers analysis, both testicular and breast cancer survivors were able to change their designation from obese to overweight. A previous online physical activity intervention in young adult cancer survivors reported a 2.1-kg weight loss over the course of 12 weeks in the intervention group compared with the control group (50); we reported an overall weight loss of 3.2 kg over a 6-month and 4.8 kg over a 12-month period. Internet interventions for weight loss that specifically incorporated a feedback component by personalized emails, automated messages or chat rooms have produced weight losses of 4–7 kg over 6 months to a year (61). Therefore, although this is a single-arm study, our findings for both male and female cancer survivors (and across both completers and intention-to-treat methods) are generally consistent with literature.

Similar to other physical activity interventions in young adult cancer survivors (49,50), few adverse events were reported, suggesting the safety of this web-based programme. However, studies do show that breast cancer survivors who participate in weight-lifting, vs. those who do not, report higher rates of injury (62). Thus, we would suggest conducting baseline physicals and well-being assessments to help address the healthcare needs of younger cancer survivors interested in weight loss (62).

This pilot study has a number of limitations, namely, the study lacks a treatment comparison group and is limited by sample size, particularly when stratifying by gender. However, most physical activity interventions in cancer survivors have focussed on female cancer survivors (20,51). Younger male cancer survivors compose 35% of the study population, and this study provides insights into this understudied group. The sample was mostly Caucasian and highly educated, which limits generalizability. Additionally, the measurement error of body fat percentage is around 3–5%, which could limit findings. Further, adherence rates are self-report, and participants have an incentive to inflate their adherence rates. Participants who are 80% compliant receive a reimbursement of the monthly fees at the end of the study. However, there was a high degree of correlation between self-report adherence and clinically measured weight loss (r = 0.80; p value = 0.04), so it is unlikely that participants inflated their self-reported adherence for financial incentives. Further, the direct correlation between self-report adherence and weight loss also suggests that the observed weight loss in this study is likely attributable to the intervention content; however, these efficacy results are preliminary and need to be tested in a randomized controlled trial. For single-arm studies in general, there is also a lack of consensus on how to analyse and report weight loss data. The underlying assumptions of both intention-to-treat and completers analyses can introduce error and bias into a study (44); however, our overall conclusions appear to be similar across these statistical approaches.

Using a commercially available programme, we were also limited in our ability to monitor user interaction with the website and how often participants reviewed specific exercises, habits, lessons, discussion boards and other website features. Further, while we evaluated the efficacy

and feasibility of this commercially available programme in terms of weight change and participation/retention/adherence rates, respectively, other studies have used additional criteria. For instance, one study suggested that study reach (i.e. ability to service willing and able participants), implementation (i.e. cost) and weight loss maintenance are also key evaluation criteria (63). By these standards, the cost of the Precision Nutrition Coaching programme at the standard price of $99/month (which is comparable with other commercially available programmes (32,33)) could be prohibitive for some patients, particularly if insurance does not provide reimbursements. Further, while the first 6 months of Precision Nutrition Coaching are generally designed for weight loss, and the last 6 months for weight maintenance (similar to other commercially available programmes (34,35)), participants continued to lose weight in the maintenance phase and retention rates were low, so additional studies would likely be needed to understand these effects. In general, criteria for evaluating the feasibility of commercially available weight loss programmes are not systematic or standard, and this is a gap in the field (63,64).

A noted strength of this intervention is the potential reach of the Precision Nutrition Coaching programme. This programme has existed for over 15 years and is designed to introduce and incorporate exercise, nutrition and lifestyle changes in a single, online and self-directed intervention (32). Thus, it could service cancer survivors that reside in more rural, low resource settings (although programme cost is still a consideration). The Precision Nutrition Coaching programme also encourages healthy eating through the gradual building of nutritional habits. This is a novel approach with preliminary weight loss results that appear comparable with other interventions that offer calorie counting, pre-fixed meals and/or food diary logs to promote healthy eating (23).

In summary, this was the first study to evaluate the Precision Nutrition Coaching programme in young adult cancer survivors, thus contributing new knowledge to the literature. This pilot study suggests preliminary feasibility, efficacy and safety of a commercially available, online weight loss programme in young adult cancer survivors. However, overall retention and self-report adherence rates are low, and additional studies are needed. Specifically, more research is needed to evaluate and compare this online weight loss programme with other academic and commercially available programmes. Findings from these studies could then be used to identify and test online weight loss programmes that promote optimal participation, retention and weight loss outcomes in younger adult cancer survivors in large, randomized trials.

Conflict of Interest Statement

Carrie T. Stricker, Justin C. Brown, David Vaughn, Susan Domchek, Sara Filseth and Andrea Branas declare they have no conflict of interest to report.

John M. Berardi is the co-founder of Precision Nutrition Coaching, and Erin Weiss-Trainor is an employee of Precision Nutrition Coaching.

Shannon M. Lynch and Kathryn H. Schmitz paid for and participated in the Lean Eating Program developed by Precision Nutrition Coaching (Lynch from January 2010 to September 2010; Schmitz from January 2013 to December 2013).

David B. Sarwer has consulting relationships with BariMD, BaroNova and Enteromedics.

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