Effect of bi-weekly supervised training sessions and prepared meals on the body weight and body composition of breast cancer survivors

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Abstract

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Breast cancer is ranked the most common cancer among Canadian women, with statistics showing that 1 in 8 women will be diagnosed with breast cancer in her lifetime. While advanced treatments contribute to higher survival rates, the quality of life to which the breast cancer survivors live is negatively affected. The psychological and physical impact of breast cancer is a challenge during and after treatment, as treatment leave sequalae for breast cancer survivors including fatigue, fear of cancer recurrence, body image issue, depression, all of which lead to a sedentary lifestyle. A sedentary lifestyle is associated with weight gain, which contributes to accumulation of fat tissue. An excess amount of weight that contributes to a high body mass index greater or equal to 25 kg/m^2 is associated with negative health outcomes including cardiovascular and metabolic diseases and co-morbidities. Particularly in breast cancer survivors, fat tissue contains properties that produce estrogen, a hormone that promotes the development of breast cancer, hence increasing the risk of recurrence of breast cancer. The inflammatory properties of fat tissue also promote the development of breast cancer. Therefore, while the survival rates of breast cancer increase, emphasis to the management of body weight should be addressed. The combination of physical activity and healthy nutrition is widely known to manage body weight in breast cancer survivors. However, the level physical activity achieved by breast cancer survivors are low, particularly women with obesity.

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List of Abbreviations

1-RM – One repetition maximum

10-RM – 10 repetitions maximum

ACSM – American College of Sports Medicine

BCRL – Breast cancer-related lymphedema

BC non-lymphedema – Breast cancer non-lymphedema

BMI – Body mass index

BRCA1- Breast cancer type 1 tumour suppressor gene

BRCA2- Breast cancer type 2 tumour suppressor gene

CSEP – Canadian Society for Exercise Physiology

FM – Fat mass

FFM – Fat free mass

MNUPAL- McGill Nutrition and Performance Laboratory

SS – Surgical side

NSS – Non-surgical side

SHBG – Sex hormone binding globulin

VO_2 – Volume of Oxygen Uptake

Chapter I

Introduction

Breast cancer is the most common cancer occurring in women around the world, making up 25% of the new cases of cancer yearly (Government of Canada, 2019). While the majority of breast cancer patients are females, breast cancer can also occur in males. One woman out of eight is likely to develop breast cancer, with an estimated 26,300 new cases of breast cancer, and 5,000 will not survive due to development of metastases, at which point the cancer is advanced and not curable (Government of Canada, 2019). Early breast cancer diagnosis and advanced effective treatments may contribute to the increased survival rate of breast cancer. While the survival rate increases, breast cancer survivors are more likely to live with consequences from the treatments, making breast cancer one of the most significant health problems.

The breast tissue extends from the axilla to the sternum, making the mammary glands which is composed of fat cells and lobules. A network of ducts within the mammary gland carries milk from the lobules to the nipple. Breast cancer is a result of abnormal cell growth, which originally starts within the cells of the mammary gland and spreads through the regional lymph nodes, bloodstream, or both. Breast cancer comprises two types: carcinoma in situ or invasive cancer. Carcinoma in situ consists of cancer cells that spread within ducts, also called ductal carcinoma, or lobules, also called lobular carcinoma, but both types of carcinoma do not extend to the stromal tissue of the breast (Akram et al., 2017). Ductal carcinoma consists of cancer cells starting from the ducts and is detected only by mammography. It comprises 90% of all in situ breast carcinomas and 70% of all invasive breast carcinomas (Snoj et al., 2010). Lobular carcinoma in situ consists of cancer cells beginning from the lobules and can be multifocal and bilateral (Inoue et al., 2017). Invasive breast carcinomas refer to cancer spreading to other tissues, commonly the liver, the bones, and the lungs (Ma et al., 2015).

Knowing the cause of breast cancer helps doctors treat the cancer more efficiently. An estrogen-receptor positive tumor and progesterone-receptor positive mean that the estrogen and progesterone hormones bind to their respective receptors within the breast cancer, which promote the modification of DNA and cell division (Lange & Yee, 2008). The human epidermal growth factor receptor 2 (HER2) controls the growth of protein on the surface of the breast cells (Iqbal & Iqbal, 2014). However, a tumor may develop as the HER2 is overexpressed and there are too many copies of this gene (Iqbal & Iqbal, 2014).

Risk factors

Age and sex are risk factors for breast cancer. Women are more likely to develop breast cancer compared to men. In Canada, 83% of the women diagnosed with breast cancer are over 50 years of age (Government of Canada, 2019).

Estrogen is a hormone produced by the ovaries in the first half of the menstrual cycle. Estrogen is in the forms of estradiol before menopause, estriol during menopause, or estrone after menopause (Elder & Thacker, 2016). Estrogens can bind to the estrogen receptors in the breast cells to stimulate the growth of milk ducts in the breasts (Brisken & O'Malley, 2010). Estrogen exposure influences the development of breast cancer. The lifetime exposure of estrogen is longest as women starts the menarche at a younger age, reaches menopause at a later age, or increases adipose tissue, or a combination of the factors (Dall & Britt, 2017). In hormone receptor-positive breast cancer, the estrogen receptor stimulates the growth of the breast cell in an uncontrolled way (Lange & Yee, 2008).

Genetic factors influence the mutation in breast cancer type 1 (BRCA1) and type 2 (BRCA2). BRCA1 and BRCA2 are proteins that repairs damaged DNA (Mehrgou & Akouchekian, 2016). Inherited mutations in BRCA1 and BRCA2 affect the normal functions of the genes, and additional genetic alterations can develop several types of cancer, notably breast cancer in female (Mehrgou & Akouchekian, 2016). Parents who carry mutated BRCA1 or BRCA2 increase the child's risk of carrying the genes by 50% (National Cancer Institute, 2018).

Weight gain occurring during early adulthood, midlife, and during menopause increases the risk of postmenopausal breast cancer (Alsaker et al., 2013). According to a population-based case control study of breast cancer, each additional five kilograms of body weight gain during adulthood is associated with an increased risk of 4% of breast cancer in postmenopausal women (Han et al., 2006). Being overweight or obese increases the risk of developing breast cancer. A study demonstrated that a body mass index (BMI) greater than 24.9 kg/m^2 increases the risk of postmenopausal breast cancer by 1.5 to 2 times (Ligibel et al., 2019). In particular, postmenopausal women with excess amount of body fat are more likely to develop estrogen receptor-positive and progesterone receptor-positive breast cancers, in addition to advanced disease and death, as the adipose tissue is the main site to produce estrogen after menopause (Neuhouser et al., 2015). Women with obesity are prone to produce estrone and estradiol two times more than women without obesity (Warren et al., 2015).

The adipose tissue contains properties that produce hormones that contributes to the development of cancer. The adipose tissue converts androstenedione to estrone, a weak form of estrogen (Dieli-Conwright et al., 2018). An abnormal increase of estrogen level may lead to growth of tumor (Siiteri, 1987). The adipose tissue also stimulates the synthesis of aldosterone, which affects the activity the adrenal gland (Siiteri, 1987). Stimulation of the adrenal secretory activity produces precursors of androgen, which has the ability to increase level of estrogen in the peripheral tissues (Siiteri, 1987). The adipose tissue may also contribute to increase inflammation as it has properties to produce pro-inflammatory cytokines, including interleukin-6 (IL-6) and tumor necrosis factor (TNF) which stimulate chemokines that attract neutrophils (Dinarello, 2006). Neutrophils are white blood cells that promote the progression of cancer and metastasis (Wu et al., 2019).

Signs and symptoms before and after breast cancer

Identifying the signs and symptoms of breast cancer is important because an early detection of breast cancer is key to improve treatment outcomes. Signs and symptoms of the development of breast cancer include the appearance of lump in the breast or the axilla, changes in the shape or size of the breast or the nipple, and abnormal discharge from the nipple.

The treatments of breast cancer often leave side effects that may affect the quality of life of the breast cancer survivors. Chronic fatigue commonly occurs after treatment of several types of cancer, including breast cancer (Morrow et al., 2002). Cancer-related fatigue differs from general fatigue, as it is not proportionally related with the level of exertion and is not alleviated by sleep or rest (Morrow et al., 2002). Cancer-related fatigue lasts for a longer duration and higher degree of severity, affecting the capacity to work and to engage in social activity. Fatigue in breast cancer occurs as early as the initiation of treatment, including surgery, radiation, and chemotherapy, and fatigue may last for up to ten years post-treatment (Bower et al., 2006).

Weight gain associated with chemotherapy is commonly experienced by the majority of patients. The Women's Healthy Eating and Living study states that women who underwent chemotherapy have a 65% greater chance of gaining weight, which could be attributed to being sedentary (Pierce et al., 2007).

Breast cancer-related lymphedema (BCRL) is a common symptom that occurs in women following cancer treatment, with the incidence ranging from 5% to 56% (Ozaslan & Kuru, 2004). The wide range is due to having no standard guidelines for diagnosing lymphedema. Lymphedema is a chronic symptom that can occur within three years of breast cancer treatment (Norman et al., 2009). The type of treatment received and the number of nodes removed may correlate with the risk of developing lymphedema. The incidence of BCRL ranges from 10-56% in women who undergo axillary lymph node dissection, a method that consists of extracting on average 10-20 lymph nodes in the armpit to detect the presence of cancer (Kwan, 2010). The incidence of BCRL is less in women who undergo sentinel lymph node biopsy, with a range of incidence between 0-23% (Kwan, 2010).

Treatment of breast cancer

Several forms of treatment have side effects that affect the quality of life of breast cancer survivors. Surgery, radiotherapy, and systemic therapy are different treatments that can be used separately or in combination to treat breast cancer.

Surgery is commonly the primary treatment of breast cancer. Patients undergoing a lumpectomy have a partial portion of the breast removed. A mastectomy consists of removing the complete breast and depending on what type of mastectomy the patients are undergoing; the muscle and the lymph nodes may be affected. Axillary lymph node dissection consists of removing the lymph nodes located in the axilla. Depending on the severity of the breast cancer, the removal of lymph nodes can vary between one to ten or more. Sentinel lymph node biopsy is a less invasive surgery that consists of removing the first lymph node that filters the fluid containing the breast cancer away from the breast tissue. McLaughlin et al. (2008) reported that although there is still a clinical risk of lymphedema, breast cancer patients who undergo sentinel lymph node biopsy are less likely to develop lymphedema five years post-treatment compared to those who undergo sentinel lymph node biopsy followed by axillary lymph node dissection. The removal of lymph nodes disrupts the axillary lymphatic system by obstructing the drainage channels, which impede the extraction of the lymph fluid out of the affected area (Campbell & McTiernan, 2007). This causes the protein, cells, and fat to remain in the interstitium (Campbell

& McTiernan, 2007). Eventually, the amount of protein present in the subcutaneous tissue in the arm will increase, causing inflammation in the limb (Campbell & McTiernan, 2007). As a result of the infection, the tissue becomes less distensible and the weight of the arm increases (Campbell & McTiernan, 2007). The subcutaneous and lymph vessel eventually become fibrotic as a result of the inflammation (Campbell & McTiernan, 2007). Larson et al. (1986) reported the risk of lymphedema development is correlated with the amount of lymph nodes removed. The authors reviewed the records of 475 women with early breast cancer who received axillary irradiation. Of the 475 patients, 240 underwent axillary surgery and the risk of lymphedema is 37% for the patients who had full dissection compared to 8% for the patients how had partial axillary lymph node dissection (Larson, 1986). The risk of lymphedema six years post-treatment was 28% when more than ten nodes were dissected; whereas, the incidence drops to 9% when less than ten nodes were dissected (Larson, 1986).

There is no standard definition for breast cancer-related lymphedema. The criteria that is the most commonly used is a difference of at least 200 milliliters of volume between the affected and the unaffected arm (Yang et al., 2018). On the other hand, a difference in circumference of at least two centimeters between the affected and unaffected arm can also indicate the presence of lymphedema (Armer & Stewart, 2005). Lymphedema could occur on the hands, arms, shoulders, legs, trunk, head, or neck. Since the surgery for breast cancer occurs on one side of the upper body, the inflammation mostly occurs on the arm of the affected side.

Tamoxifen is a common medication prescribed during treatment and as a preventative option of breast cancer after the treatment to reduce the recurrence of breast cancer. Tamoxifen inhibits the action of estrogen which reduces the incidence of breast cancer by 50-75% (Cummings et al., 2000). Weight gain is commonly recognized as a side effect of tamoxifen, especially during the first 12 months of treatment (Sestak et al., 2012). Although weight gain is often reported by women taking tamoxifen or anastrozole after the cancer is cured, a clinical trial reported no independent effect of tamoxifen or anastrozole on weight change (Sestak et al., 2012).

Physical activity and breast cancer

Physical activity is widely known for its positive outcomes in different type of population, including breast cancer survivors. Treatment of breast cancer leave side effects that negatively affect the quality of life of breast cancer survivors due to several signs and symptoms including chronic fatigue, weight gain, depression, and sleep disturbances. Risk of cancer is associated with a sedentary lifestyle due to different mechanisms including a higher insulin-resistance and C-reactive protein systemic inflammation and weakening of the function of the immune system by not stimulating the t-helper cells (Campbell & McTiernan, 2007). Several studies demonstrate promising benefits of physical exercise in breast cancer survivors similar to general apparently healthy population such as improved immune function, energy level, cardiopulmonary function, moon, and quality of life. Physical activity reduces the risk of developing new case of breast cancer, breast cancer recurrence, and increase the survival rate.

Different mechanisms may explain the role the protective effect of physical activity. Physical activity decreases level of estradiol in premenopausal women and decreases level of estrone in postmenopausal women, both of which reduce the risk of breast cancer development (Cleary & Grossmann, 2009). As the adipose tissue is the main source of estrogen production in postmenopausal women, increased amount of physical activity reduces level of adipose tissue, which reduces the risk of the development of breast cancer by reducing the amount of production of estrogen (Cleary & Grossmann, 2009).

Insulin and IGF-1 are both factors that promote the development of breast cancer, as they have properties that stimulate the activity of estrogen synthase, and therefore increase level of estrogen (Meneses-Echávez et al., 2016). Insulin and IGF-1 also decreases the secretion of sex hormone-binding globulin from the liver, which is a steroid-binding plasma glycoprotein that inhibits the production of estrogen. Exercise reduces the level of insulin and IGF-1, which is beneficial in reducing the level of estrogen in the body (Meneses-Echávez et al., 2016).

Increasing the level of physical activity also helps with management of body weight and improve the body composition. As stated earlier, the adipose tissue becomes the main site for the production of estrogen after menopause, and increasing the level of physical activity will reduce the amount of adipose tissue, hence less production of estrogen. A study demonstrated that after a 16-week of supervised training sessions that included aerobic and resistance training three times per week, obese postmenopausal breast cancer survivors experienced a significant improvement in body composition and systematic inflammation, with a significant decrease in adipose tissue and increase secretion of anti-inflammatory cytokines (Dieli-Conwright et al., 2018).

A 6-month weight training intervention in which breast cancer survivors were supervised in groups of four participants by qualified exercise professionals twice per week for 13 weeks demonstrated an improvement in physical and psychosocial quality of life through an increase in lean muscle mass and increase in upper body strength (Ohira et al., 2006).

Nutrition and breast cancer

The National Cancer Institute recommends a dietary change for breast cancer survivors, by consuming a diet high in fruits and vegetables, high in whole grains, and low in fat (National Cancer Institute, 2018). The dietary guideline aims to prevent the recurrence of cancer. Studies show a diet containing high amount of omega-3 fatty acids, as much as three times more than the recommendation for healthy individuals, is beneficial as this nutrient contains potential anticarcinogenic compounds and chemical properties that inhibit the growth of breast tumors and induce death of breast cancer cells (Fabian et al., 2015; Rovito et al., 2015). Sources of omega-3 fatty acids include fish such as salmon, canned tuna, white fish, as well as olive oil. Lignan is a nutrient with properties that are anticarcinogenic and that alters the metabolism of estrogen in the body. Lignan are phytoestrogens with chemical structure that are similar to an estrogen molecule (Calado et al., 2018). Lignan can decrease cell growth located in the breast tissue and prevents cell proliferation by enhancing apoptosis (McCann et al., 2010). Lignan is found mainly in flaxseeds, but also in soy, whole grains, and some fruits such as peaches (Murkies et al., 1998). Dietary fibers contain properties capable of decreasing the level of estrogen in the circulating blood. Higher intake of dietary fiber reduces the risk of breast cancer, in particular postmenopausal women (Pierce et al., 2007). Canadian women are not meeting the recommended intake of omega-3, lignan, and dietary fibers, which is a concern as breast cancer is the most common cancer in Canadian women (Calado et al., 2018).

Chapter II

Effect of bi-weekly supervised training sessions and prepared meals on the body weight and body composition of breast cancer survivors.

Abstract

Introduction: Lifestyle intervention targeted for breast cancer survivors is important as the treatments for breast cancer leave sequelae affecting their quality of life. Weight gain is a common side effect after the treatment of breast cancer and presents with physiological factors that may contribute to the recurrence of breast cancer. The aim of this pilot study is to evaluate the effect of supervised training sessions and dietary interventions on the body weight and volume of the arm of breast cancer survivors.

Methods: Nineteen women were recruited, including 11 with breast cancer-related lymphedema (BCRL). Participants received prepared breakfast and lunch meals (total calories = 717 kcals) for 5 days per week over the 12-week period. The participants followed an exercise program, supervised by kinesiologists twice a week, one hour each session for 10 weeks. The participants continued with the same exercise program without supervision for an additional 12 weeks. Body weight and arm volume were obtained at baseline and at week 10.

Results: The primary outcome measures were body weight and arm volume. The preliminary results showed a significant reduction in body weight ($p=0.007$), body mass index ($p=0.007$), and arm volume of the surgical side ($p=0.003$) and the non-surgical side ($p=0.001$) after 10 weeks of intervention.

Conclusion: These preliminary results indicate that 10 weeks of supervised training sessions and dietary intervention may be an effective strategy to reduce body weight in breast cancer survivors and arm volume in women with BCRL.

Key words: Breast cancer, lymphedema, exercise, diet

Introduction

While the number of breast cancer survivors rises as a result of early detection and advanced efficient treatment options, these women may experience living longer with the negative side effects from the treatments of breast cancer, including weight gain, lymphedema, poor quality of life, and chronic fatigue. Care for breast cancer survivors is important and supports the need for promoting a healthier lifestyle behaviour.

Fatigue is the most common symptom experienced after the treatment of breast cancer which negatively affects the level of physical activity of breast cancer survivors (Meeske et al., 2007). Fatigue also contributes to a sedentary lifestyle and weight gain. Body mass index (BMI) is an indicator of health risk. As BMI increases above 24.9 kg/m^2, there is an increased risk of developing cardiovascular disease, metabolic disease, and co-morbidities. Weight gain occurs in 50-96% of women during treatment of breast cancer, which commonly happens in premenopausal women receiving adjuvant chemotherapy (Freedman et al., 2004). Weight gain occurs at a faster rate in breast cancer survivors during the first five years after cancer treatment, in particular after chemotherapy (Gross et al., 2015). The risk increases proportionally with the duration of the treatment and with the presence of obesity (Dignam, 2003). The association between obesity and breast cancer especially in postmenopausal women may also be related to estrogen activity as this hormone is strongly linked to an increase in breast cancer risk (Dignam, 2003).

Increase of fat tissue and decrease in lean tissue results in reduced metabolic activity, hence less calories expended. In particular, fat deposit around the visceral organs, also known as visceral fat, is reflected by the circumference of the waist. A greater visceral fat is associated with negative health risk. A reduction of waist circumference is linked with a lower risk of obesity-related cancer risk (Luo et al., 2019).

In addition to weight gain that occurs during and after the treatment of breast cancer, lymphedema is a common side effect that may occur within the first three years post-treatment, with the risk ranging from 5% to 56% (Ozaslan & Kuru, 2004). The large range is due to the lack of standardized diagnosis of lymphedema. Breast cancer-related lymphedema (BCRL) is the inflammation of the lymph and occurs generally due to treatment of breast cancer that disrupts the lymphatic system, particularly around the axillary nodes. While several studies demonstrated that obesity increase the risk of BCRL, some also report that lymphedema may also lead to obesity, suggesting a reciprocal relationship between obesity and lymphedema (Mehrara & Greene, 2014). The excess of body weight may increase the risk of developing BCRL, with the severity of lymphedema being positively correlated with the degree of obesity (Fabian et al., 2015). A prospective study shows that women with breast cancer and BMI greater than 30 are three times more likely to develop lymphedema compared with women with breast cancer and BMI less than 25 (Helyer et al., 2010). An impaired lymphatic function can develop excess adipose deposition and obesity (Mehrara & Greene, 2014). Women who are affected by lymphedema experience signs and symptoms on the affected arm, including a larger arm circumference, heavier arm on the affected side, pain, discomfort, limited range of motion, in addition to psychosocial consequences such as body image disturbance and decreased quality of life, all of which being a barrier to become physically active (Norman et al., 2009). As the lymphedema develops, it becomes irreversible once it reaches the second stage. To date, there are no known cures for lymphedema; therefore, special care is critical to manage the signs and symptoms. It was previously believed that exercise is contraindicated in women affected by lymphedema. Recent studies demonstrated positive outcomes with regular training sessions at low, moderate, and high intensity, including a better quality of life (Wanchai & Armer, 2019).

As women are more likely to gain weight after the treatment of breast cancer, a healthy nutrition is important to manage body weight and to decrease adverse health risks. In addition to a reduced metabolic activity post-treatment, a caloric imbalance with the energy intake being greater than the energy expenditure results in weight gain. Breast cancer survivors are advised to modify their nutritional habits to meet their daily nutrition needs including a higher amount of omega-3 intake, that is three times more than the daily recommendation for healthy individuals, and higher amount of fiber intake (Fabian et al., 2015). The recommendations are accommodated such to reduce the risk of recurrence of cancer and to decrease the inflammation.

Reaching the minimum recommendation of 150 minutes of physical activity at moderate to vigorous intensity, as recommended by the Canadian Society of Exercise Physiology (CSEP), may not be feasible for women after the treatment of breast cancer. Several barriers affecting the physical activity level of breast cancer survivors include diminished level of confidence, chronic fatigue, and limited ability to move caused by the signs and symptoms post-treatment (Bower, 2014). A cohort study reported that among the 32% of 806 breast cancer survivors who met the physical activity recommendation, a small portion of participants had BMI in the obese category

(Irwin et al., 2010). Nonetheless, the CSEP guideline reports some health benefits and improved functional abilities even if the amount of physical activity is below the recommended levels, providing the volume of exercise gradually increases until the guideline is met.

Knowing that breast cancer survivors are more likely going to continue to live with the side-effects from the treatment, reducing the weight is a strategy to decrease the risk of cancer recurrence as well as the signs and symptoms related with cancer. To our knowledge, no studies involving weight loss in breast cancer include a rigorous method whereby participants are closely monitored in both exercise and nutrition. The purpose of this pilot study is to evaluate the feasibility of a 22-week intervention combining supervised training sessions and prepared meals and its effect on the body weight and body composition of the breast cancer survivors. We hypothesized that the combination of exercise and dietary intervention would generate a clinical meaningful reduction in body weight by 5-7%. We also hypothesized that the combination of exercise and dietary intervention would significantly decrease the volume of the affected arm of the women with BCRL. The present article reports the preliminary results that reflects the changes over the first 10 weeks period that includes the supervised training sessions and the prepared meals intervention.

Methods

Study design and participants

Study Design: This prospective study was a single group, pre-post test, quasi-experimental pilot. Approval to conduct the study was provided by the Human Research Ethics Committee of Concordia University. The participants were recruited from the Lymphedema Clinic at the McGill Nutrition and Performance Laboratory (MNUPAL) and from the PERFORM Centre affiliated with Concordia University in Montreal. A total of 19 female breast cancer survivors were recruited, of which 11 have breast cancer-related lymphedema. The inclusion criteria were that they must be above 18 years old; body mass index greater than or equal to 25 kg/m^2; participating in less than 60 minutes of vigorous physical activity per week; has no recurrent cancer; has no bilateral lymphedema. The exclusion criteria were that they must not have a diagnosis of uncontrolled heart disease, hypertension and diabetes; has bilateral lymphedema; has recurrent cancer; still undergoing treatment for cancer; following a personalised diet.

Flyers describing the purpose of the study were posted in the waiting area of the Lymphedema clinic and inside the consultation room. The doctor specialized for the lymphedema sent personal e-mail to physiotherapists and kinesiologists about the study to refer patients to the study. The researcher went regularly at a frequency of once per week to meet with potential participants who may be eligible to participate in the study. Flyers were posted on the wall and on the television screen on the conditioning floor at PERFORM Centre. The participants were contacted by e-mail, by phone, and in person by the researcher to confirm the eligibility criteria. Two orientation sessions were hosted to gather all potential participants in one room at PERFORM Centre, where the researcher explained in detail the study. Recruitment took place between October 2018 to September 2019. Prior to recruitment, all participants signed a written informed consent. While all participants were aware of the purpose of the study, all participants were blinded from the data obtained until the participants completed the study. All interested participants were asked to complete forms and questionnaires, including the informed consent, the adult medical history form, the waiver form, and the Physical Activity Readiness Questionnaire (PAR-Q+). After completion of the forms and confirmation of study enrollment, the clinical exercise physiologist and the dietician proceeded with booking the appointments for the fitness assessment and for the nutrition counselling.

Protocols

The participants followed a progressive training program twice per week for 22 weeks which included aerobic, resistance, and stretch exercises (Appendix A). All women with BCRL were advised to wear compression garments while exercising. Certified exercise professionals and interns from the Health, Kinesiology and Applied Physiology program specialized in Clinical Exercise Physiology of Concordia University supervised the first 10 weeks of bi-weekly training sessions of each participants. The participants were followed individually by the certified exercise professionals and the interns. The role of the certified exercise professionals and the interns served to ensure a safe training session while monitoring exercise progression. The participants continued to follow the training program for the remaining 12 weeks, with self-progression. Adjustments to the training program were made on individual basis based on the perceived exertion of the participants. All participants with BCRL (n=11) were advised to wear a compression sleeves during the training sessions.

The training sessions were monitored using a SmartKey which uses the TechnoGym program. The participants were instructed on the usage of the SmartKey.

Nutrition counselling including the 24-hour recall was done by the dietician at baseline, at 10 weeks, and at 22 weeks. The dietician also provided dietary advice for each participant, with the goal to reduce daily caloric intake by 500 kilocalories per day in order to achieve a healthy body weight reduction of one to two pounds per week.

Participants were asked to collect two sets of food bags once a week for 12 weeks (Appendix B). Each pair of bags contained 10 meals including breakfast and lunch, with both meals contributing to 717 kilocalories on average (Appendix C). Each participant was expected to consume the 10 meals in one week. The dinner was not included in the meal bags. The participants were responsible for the remaining dinner meal to complete their daily food intake, keeping in mind their daily recommended needs that was discussed during their nutrition counselling.

Three cooking classes were offered after 12 weeks of the study. Each cooking class had a different theme to promote healthier eating behaviour, namely “Lower salt and sugar contents in the meals”, “The importance of Omega-3”, and “Cooking vegan meals”. Each participant was invited to assist in two of the three cooking classes. At the end of each cooking class, the participants took the food home.

After completion of the study, each participant was contacted by phone for an exit survey of approximately 45 minutes. The interview was audio-recorded on the phone and the women discussed about their opinion and thoughts of participating in the study, and how it changed or did not change their daily routines.

Study outcomes

All assessments were taken at PERFORM Centre in the Kinesiology Clinic. We assessed the participants at baseline, at 10-weeks, and at 22-weeks. All participants fasted and avoided strenuous physical activity at least 6 hours prior to each assessment. The primary outcomes were changes in body weight and volume of the arm.

Anthropometric measurements

Resting heart rate was measured manually by locating the radial nerve of the participant. The number of beats per minute was obtained by multiplying the number of pulses in 15 seconds by four. Resting blood pressure was measured manually using the sphygmomanometer and stethoscope.

Height was measured using the stadiometer. The tester asked the participant to remove shoes, to stand with the heel, buttocks, upper back, and head in contact with the stadiometer, with feet together. The height measurement was obtained as the participants inhale. The height measurement was recorded to the nearest 0.5 centimeters.

The body weight was measured using an electronic body weight scale. The participants were asked to remove shoes and to stand on the scale. The weight measurement was recorded to the nearest 0.1 kilograms.

Circumference of the waist was measured using a tape measurement, which was wrapped around the waist of the participant, at the level of the superior edge of the iliac crest. The circumference of the waist was recorded to the nearest 0.5 centimeters.

The circumference of the hip was measured using a tape measurement, which was wrapped around the maximal extension of the buttocks. The circumference of the hip was recorded to the nearest 0.5 centimeters.

The body composition was measured using the ImpediMed SFB7, which provided information about the total body water content, the extracellular fluid, the intracellular fluid, the fat mass, and the fat free mass. The bioimpedance unit was calibrated prior to each measurement performed. The participants were lying supine on a massage bed. Prior to taking the measurements, the participants rested for five minutes. During the five minutes of rest, the tester applied four electrodes on the right side of the body; the first electrode was placed on the wrist at the level of the ulnar styloid process, the second electrode was placed five centimeters apart from the first electrode, the third electrodes was placed on the ankle at the level of the medial and lateral malleolus, and the fourth electrode was placed five centimeters apart from the third electrode.

The volume of the arm was measured using the circumferential tape method, adapted by the Lymphedema Clinic at the MNUPAL. The measurements were taken without comparing previous measurements from prior visit to reduce bias. The participants were seated on a chair, with both arms extended and pronated against a pillow on the thigh. The tester measured the circumference of the palm, the wrist, the forearm, the elbow, the midarm, and the axilla. The measurements of each circumferences were included in the truncated cone equation to obtain the volume of the different segment of the arms. The volume of the arm was obtained by summing each volume of the segment of the arm.

Balance

The unipedal stance test was performed to assess the static balance. The test protocol was adapted from the CSEP-PATH. The participants stand barefoot on one leg with arms crossed over the chest while focusing on a marker at eye level for a maximum 45 seconds. The time stops if the participants uncross arms, touches the floor with the opposite foot, rotate the weight-bearing foot on the floor, or reach 45 seconds. The participants then switch leg and repeat the same procedure. The participants will perform the same test with eyes closed.

Muscular strength and endurance

A hand dynamometer was used to assess the handgrip strength, adapted by the CSEP-PATH protocol. Two trials were performed per side and the best score of each side was summed to obtain the total handgrip strength.

The upper body strength was assessed using the 10-repetitions maximum (10-RM) Smith machine bench press. The participants were asked to lift the assigned weight for 10 repetitions until they reach their 10-RM. All participants were allowed to perform a maximum of five trials.

The lower body strength was assessed using the 10-RM leg press. The participants were asked to lift the assigned weight for 10 repetitions until they reach their 10-RM. All participants were allowed to perform a maximum of five trials.

The upper body endurance was assessed using the 30 seconds arm curls with a five pounds dumbbell and the 30 seconds single arm cable triceps pushdown with two and a half pounds. The participants were asked to perform as many repetitions as possible during the 30 seconds in a safe and correct manner.

Flexibility

The flexibility of the lower leg was assessed using the chair sit-and-reach test adapted from the senior fitness test. The measurements were recorded in inches for each side. The participants were seated on a chair. The participants were asked to have one leg extended at the knee with the toes pointing to the ceiling while the opposite leg is relaxed with the knees bent at 90 degrees. The scoring leg is the leg that is extended. While keeping the spine neutral, the participants had two hands on top of the other. The participants were asked to take an inhale before exhaling and bending at the level of the hip to bring the hands with arms extended towards the toes. The distance was measured from the tip of the middle finger to the toes. If the fingers of the participants reached past the toes, the score is positive. If the fingers of the participants are behind the toes, the score is negative.

Nutrition

The food was prepared in the metabolic kitchen of the PERFORM Centre by the dietitian and students from the Human Nutrition program at the McGill University. The students were trained with sanitary procedures and cooked fresh produces that were delivered to PERFORM Centre every week. All baked and cooked foods were kept in the freezer while all fresh produce was kept in the fridge until they were provided to the participants. Women who had restrictions or allergies to certain food were provided with an alternative option with equivalent nutrient content. The 24-hour dietary recall was used by the registered dietician at baseline, at week-10, and at week-22 to record all foods and beverages consumed in the past 24 hours.

Statistical analysis

Due to a small sample size and to a lack of control group, all the variables were compared using the Student T Test to look at the differences from baseline to week 10 of the intervention. The normal distribution was statistically tested using the Shapiro-Wilk statistics. All variables are normally distributed except for weight, BMI, arm volume of the surgical side, arm volume of the non-surgical side, fat mass, and chest press. For those variables, the Wilcoxon-test was used for comparisons. The Pearson correlation test was used to analyse the correlation between body weight and the volume of the surgical arm volume of the participants with BCRL, as those variables were shown to be normally distributed according to the Shapiro-Wilk statistics. The effect size was measured by dividing the mean difference of two groups over the average standard deviation. An effect size ranging from 0.2 to 0.5 is classified as small, 0.5 to 0.79 is classified as medium and an effect greater than 0.8 is large (Sullivan & Feinn, 2012).

Results

We approached 35 women with a history of breast cancer and we recruited 21 eligible participants. We refused a woman who had bilateral lymphedema (n=1), women with a BMI lower than 25 kg/m^2 (n=2); women with a diet restriction, either they are vegetarian (n=1) or eat kosher food only (n=2). Although interested, some women did not want to participate in the study because some women would not want to travel to the research centre due to distance (n=5), some women had family or holiday commitments over the study period (n=2), and one woman who did not think she could add a new routine due to her full-time job (n=1). The baseline characteristics of the participants recruited are presented in Table 1.

Table 1: Baseline characteristics of the breast cancer survivors

	Combined (N=19)		**BCRL (N=11)**		**BC non-lymphedema (N=8)**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Age	62	8	62	8	63	9
Breast cancer diagnosis	2008	10	2009	9	2007	10
Side of surgery						
Left	7		4		4	
Right	10		6		3	
Both	2		1		1	
Treatment of cancer						
Chemotherapy	15		10		5	
Radiotherapy	15		10		5	
Treatment during the study						
Tamoxifen	1		1			

	Aromatase inhibitor	4		3		1	
Lymphedema onset				2010	9		
	Left			5			
	Right			6			
BMI (kg/m^2)		33.6	6.9	35.2	6.5	31.4	7.2
	Overweight	8		2		6	
	Obese	4		4		0	
	Severely obese	4		3		1	
	Morbidly obese	3		2		1	
Weight (kg)		87.6	19.6	91.5	19.7	82.1	19.4
Waist circumference (cm)		107.7	11.0	106.3	9.0	104.6	13.2
Absolute fat mass (kg)		36.0	11.9	38.6	13.1	32.5	9.7
Absolute fat free mass (kg)		52.1	8.7	53.9	7.2	49.7	10.4
Relative fat mass (%)		40.0	5.1	40.7	5.7	39.1	4.2
Relative fat free mass (%)		60.0	5.1	59.3	5.7	60.8	4.2

Nineteen participants completed the 10-week exercise and dietary-intervention. Two participants did not complete the 10-week period of the study because of the complications with transport and one woman had a car accident and suffered back pain. The preliminary results of the 10-week intervention are presented in Table 2 and Table 3.

Table 2: Comparison of fitness variables between baseline and week-10 of the combined group

	Baseline (n=19)	Week 10 (n=19)	Mean difference	Std. Deviation	P-value
Anthropometric measurement					
Resting heart rate (bpm)	69	73	4	7.91	**0.032***
Systolic Blood Pressure (mmHg)	128	117	-11	12.07	**0.001***
Diastolic Blood Pressure (mmHg)	73	70	-3	8.61	0.071**
Body Mass Index (kg/m^2)	33.6	32.7	-0.9	1.24	**0.007***‡

Body weight (kg)	87.6	85.2	-2.4	3.34	**0.007***‡
Waist circumference (cm)	107.7	103.2	-4.5	4.33	**0.001***
Hip circumference (cm)	118.9	115.8	-3.1	5.58	**0.010***‡
Volume of the SA (mL)	2897.5	2698.0	-199.5	243.59	**0.003***‡
Volume of the NSA (mL)	2651.8	2455.6	-196.2	211.47	**0.001***‡
Body composition					
Total body water (L)	38.2	37.2	-1.0	1.82	**0.028***
Total body water (%)	43.9	43.8	-0.1	1.34	0.868
Extracellular fluid (L)	16.2	15.9	-0.3	0.68	0.060**
Extracellular fluid (%)	42.6	43.0	0.4	0.71	0.055**
Intracellular fluid (L)	21.9	21.2	-0.7	1.22	**0.027***
Intracellular fluid (%)	57.4	57.1	-0.3	0.80	0.169
Fat mass (kg)	36.0	35.1	-0.9	2.18	0.126‡
Fat mass (%)	40.0	40.1	0.1	1.82	0.910
Fat free mass (kg)	52.1	50.7	-1.4	2.55	**0.027***
Fat free mass (%)	60.0	59.7	-0.3	1.97	0.660
Musuclar strength and endurance					
Handgrip strength (kg)	44	47	3	8.54	0.253
Leg press 10RM (lbs)	128	158	30	41.23	**0.005***
Chest press 10RM (lbs)	33	38	5	6.01	**0.005***‡
Single biceps curl on the SA (reps)	15	17	2	2.53	**0.001***
Single biceps curl on the NSA (reps)	15	17	2	2.65	**0.001***
Single triceps pushdown on the SA (reps)	23	25	2	5.14	0.116
Single triceps pushdown of the NSA (reps)	22	25	3	5.43	**0.027***
Sit and reach of the SA (in)	-3.4	-3.5	-0.1	5.80	0.985
Sit and reach of the NSA (in)	-4.2	-4.7	-0.5	3.50	0.518

*Statistically significant ($p \leq 0.05$)

**Statistical trend

‡ P-value obtained from the Wilcoxon signed-rank test

10RM – 10 repetitions maximum

SA – surgical arm

NSA – non-surgical arm

Table 3: Comparison of nutrition variables between baseline and week-10 of the combined group

	Baseline (n=19)	Week 10 (n=19)	Mean	Std. Deviation	P-value
Total energy intake					
Kcal/d	1803.8	1328.6	-475.2	1084.1	0.077‡
Carbohydrate intake					
g/d	191.6	181.3	-10.3	132.3	0.738
% of Energy	45.3	55.1	10.0	17.0	**0.020***
Total fat intake					
g/d	85.9	43.1	-42.8	72.2	**0.027***‡
% of Energy	39	29.2	-9.7	18.0	**0.030***
Protein intake					
g/d	76.7	57.7	-19.0	43.4	0.073**
% of Energy	18.0	17.0	-0.6	8.6	0.754
Fiber intake					
g/d	23.9	21.0	-4.7	21.8	0.658‡
Omega-3 intake					
g/d	1.9	1.42	-0.9	3.2	0.687‡

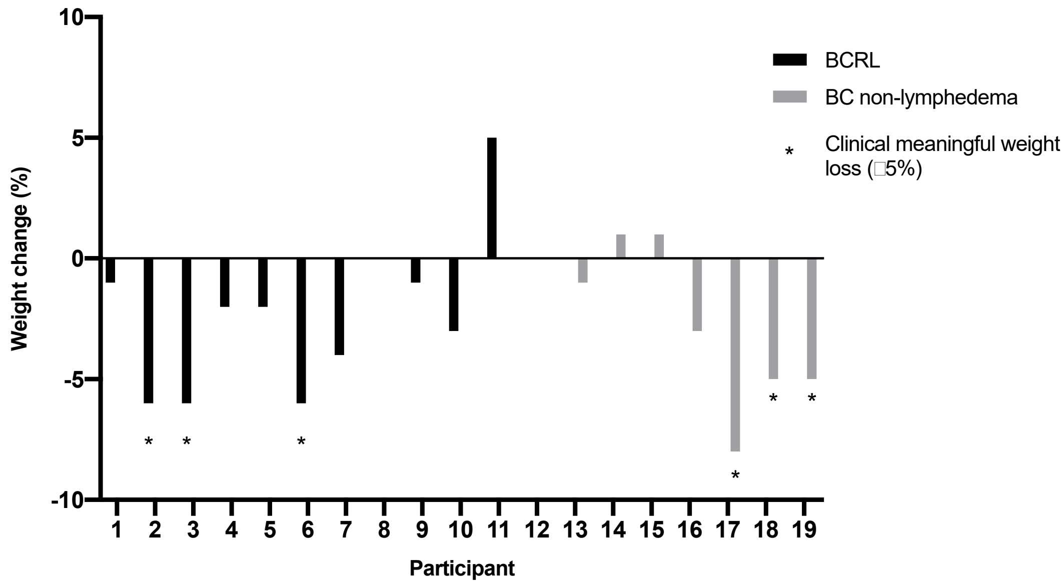
‡ P-value obtained from the Wilcoxon signed-rank test

Anthropometric measurements in breast cancer survivors

The resting heart rate significantly increased from baseline (B) to 10-weeks (B, 69 ± 9 bpm vs 10-wk, 73 ± 9 bpm, p=0.032). The systolic blood pressure significantly decreased (B, 128 ± 15 mmHg vs 10-wk, 117 ± 13 mmHg, p=0.001). The diastolic blood pressure demonstrated a statistical trend (B, 73 ± 12 mmHg vs 10-wk, 70 ± 10 mmHg, p=0.07).

The body mass index significantly decreased (B, 33.6 ± 6.9 kg/m^2 vs 10-wk, 32.7 ± 6.1 kg/m^2, p=0.006). The body weight significantly decreased (B, 87.6 ± 4.5 kg vs 10-wk, 85.2 ± 4.0 kg, p=0.007). Figure 1 demonstrates that 6 of the 19 participants achieved a clinical meaningful weight loss of at least 5% after 10 weeks.

Figure 1. Percentage of weight loss at week 10



The waist circumference significantly decreased (B, 107.7 ± 11.0 cm vs 10-wk, 103.2 ± 10.6 cm, p=0.001). The hip circumference significantly decreased (B, 118.9 ± 16.0 cm vs 10-wk, 115.8 ± 14.4 cm, p=0.025). The volume of the surgical arm significantly decreased (B, 2897.5 ± 871.8 mL vs 10-wk, 2698.0 ± 724.0 mL, p=0.002). The volume of the non-surgical arm significantly decreased (B, 2651.8 ± 721.4 mL vs 10-wk, 2455.6 ± 571.0 mL, p=0.001). Figure 2 demonstrates the reduction in volume of the arm of the surgical and non-surgical side of each participant. Within the women with BCRL, a positive significant correlation exists between the percentage of reduction of arm volume and weight loss, as seen in Figure 3 (r=0.595, p=0. 054).

Figure 2. Change in arm volume at week 10

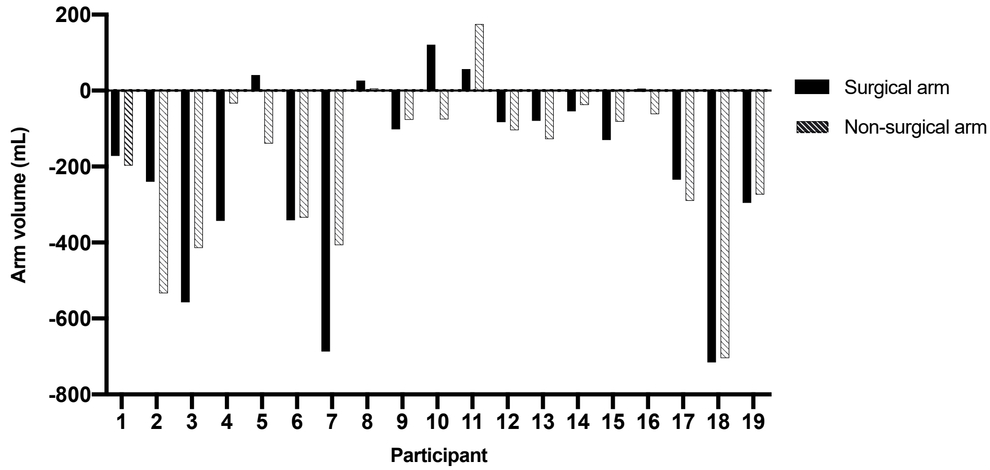
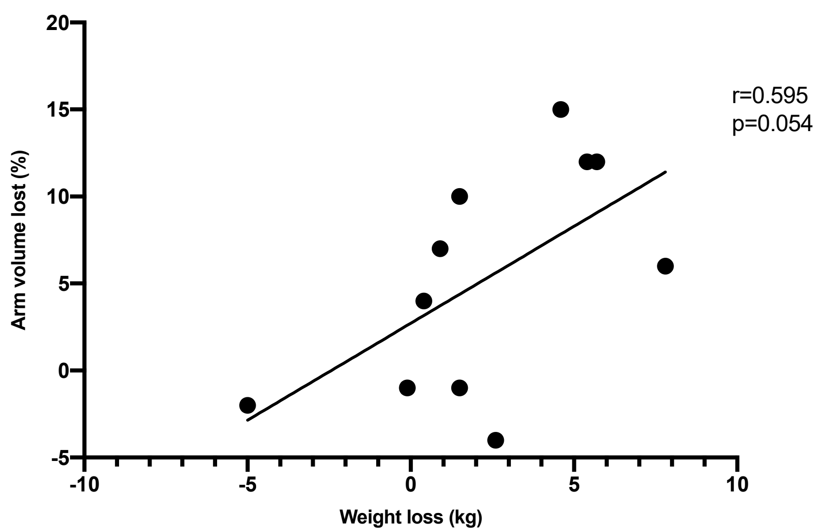


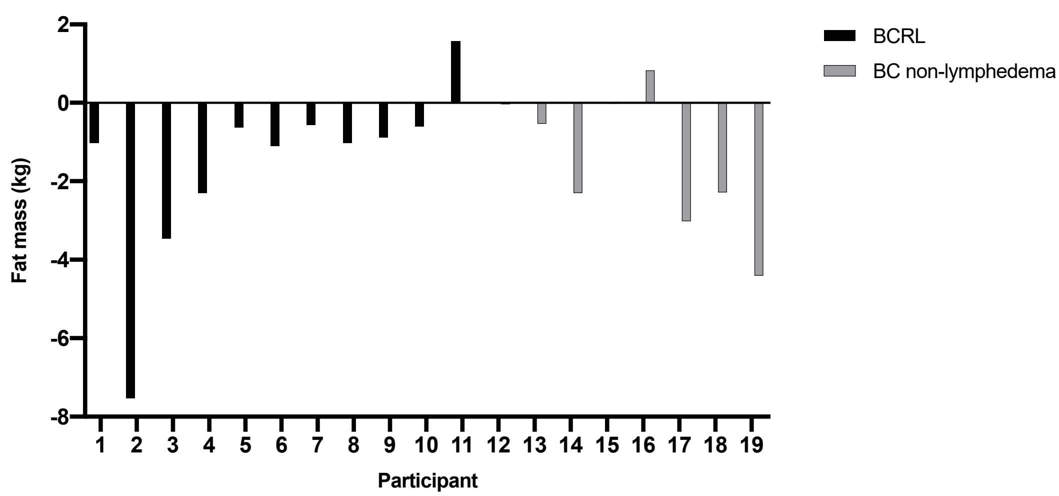
Figure 3. Correlation of changes in arm volume and body weight among women with BCRL



Body composition in breast cancer survivors

The total body water significantly decreased (B, 38.2 ± 6.4 L vs 10-wk, 37.2 ± 5.3 L, p=0.028). In relation to the body composition, the percentage to which the total body content comprised in the body did not significantly changed (B, 43.0% ± 3.7% vs 10-wk, 43.8 ± 4.0%, p=0.868). When we examine the fluid compartments, the intracellular fluid significantly decreased (B, 21.9 ± 3.8 L vs 10-wk, 21.2 ± 3.2 L, p=0.027). The absolute extracellular fluid did not significantly change but showed a statistical trend (B, 16.2 ± 2.6 L vs 10-wk, 15.9 ± 2.3 L, p=0.060). Similarly, the percentage of absolute intracellular fluid significantly changed (B, 21.9 ± 3.81% vs 10-wk, 21.2 ± 3.16%, p=0.025). The percentage to which the extracellular fluid comprise the body significantly changed (B, 42. 6 ± 1.39% vs 10-wk, 43.0 ± 1.57%, p=0.055). The percentage to which the intracellular fluid comprise the body did not significantly change (B, 57.4 ± 1.39% vs 10-wk, 57.1 ± 1.6%, p = 0.169). The change in fat mass is demonstrated in figure 4, although there is no significant change (B, 36.0 ± 11.9 kg vs 10-wk, 35.1 ± 11.5 kg, p=0.126). The fat free mass significantly decreased (B, 52.1 ± 8.7 kg vs 10-wk, 50.7 ± 7.2 kg, p= 0.027). The percentage to which the fat mass contributes to the body weight did not significantly change (B, 40.0 ± 5.1 kg vs 10-wk, 40.1 ± 5.5 kg, p= 0.910). The percentage to which the fat free mass contributes to the body weight did not significantly changed (B, 60.0 ± 5.1 kg vs 10-wk, 59.7 ± 5.5 kg, p=0.660).

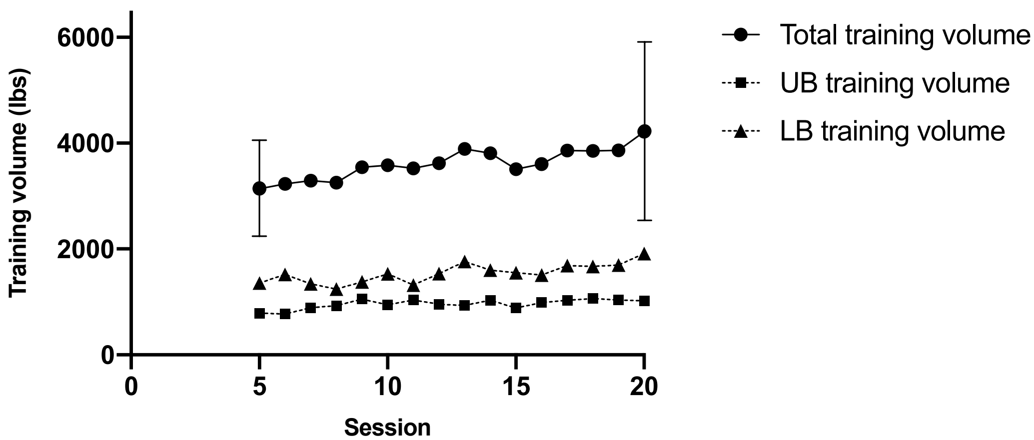
Figure 4. Change in fat mass at week 10



Total body muscular strength and endurance

A gradual increase of stress on the body is achieved by increasing the volume of the training sessions on a weekly basis to follow the progressive overload principle (Figure 5). The amount of weights lifted per session represents the training volume. Body weight and theraband exercises were introduced the first four sessions to prepare for the use of the resistance machine exercise that starts at the fifth session. The training volume significantly increased (session 5, 3138 ± 962 lbs vs session 20, 4219 ± 1915 lbs, p=0.005). From session 5-12, the participants increased their upper body and lower body training volume by 23% and 41%, respectively. The handgrip strength increased after 10 weeks of intervention, although the results are not significantly different (B, 44 ± 11 kg vs 10-wk, 47 ± 12 kg, p=0.253). The leg-press significantly increased (B, 128 ± 43 lbs vs 10-wk, 158 lbs ± 52 lbs, p=0.005). The chest-press significantly increased (B, 33 ± 8 lbs vs 10-wk, 38 ± 5 lbs, p=0.001). The number of single arm biceps curl repetition (reps) with a five pounds dumbbell on the affected side significantly increased (B, 15 ± 5 reps vs 10-wk, 17 ± 5 reps, p=0.001). The number of single arm biceps curl repetition with a five pounds dumbbell on the non-affected side significantly increased (B, 15 ± 5 reps vs 10-wk, 17 ± 5 reps, p=0.001). The number of single arm triceps pushdown repetitions on the affected side did not change significantly (B, 23 ± 7 reps vs 10-wk, 25 ± 7 reps, p=0.116). The number of single arm biceps curl repetitions on the non-affected side significantly increased (B, 22 ± 6 reps vs 10-wk, 25 ± 7 reps, p=0.027).

Figure 5. Mean of training volume progressions over 10 weeks



Training volume = Sets x Repetitions x Weight lifted

Flexibility

The sit and reach results did not significantly change on the surgical and the non-surgical side after the 10 weeks of intervention (B, -3.4 ± 3.3 in. vs -3.5 ± 5.8 in, p=0.985 and B, -4.2 ± 2.9 in vs -4.7 ± 4.9 in, p=0.518).

Effect size

The effect size indicates the magnitude of the difference between baseline and week-10. The Cohen d. The effect size is large for the systolic blood pressure (d=0.81) and chest press (d=0.82). The effect size is medium for the resting heart rate (d=0.47), waist circumference (d=0.43), leg press (d=0.64), biceps curl of the surgical and non-surgical side (d=0.44 and d=0.50), and the triceps pushdown of the non-surgical side (d=0.47). The effect size is small for the diastolic blood pressure (d=0.36), BMI (d=0.14), body weight (d=0.13), hip circumference (d=0.21), arm volume of the surgical and non-surgical side (d=0.26 and d=0.31), total body water (d=0.18), absolute and relative extracellular fluid (d=0.13 and d=0.23), absolute and relative intracellular fluid (d=0.20 and d=0.18), absolute fat mass (d=0.08), handgrip (d=0.21), triceps pushdown of the surgical side (d=0.29), and chair sit-and-reach of the non-surgical side (d=0.14). The effect size is very small for relative total body water (d=0.01), relative fat mass (d=0.04), and chair sit-and-reach of the surgical side (d=0.01).

Discussion

The study is the first to closely monitor the fitness and diet components of the intervention by combining supervised training sessions and providing prepared meals targeted for breast cancer survivors.

Following the 10-week intervention, the compliance to the training sessions and the recommended daily calories intake in breast cancer survivors was 88% and 83% respectively. The breast cancer survivors started the study with a mean BMI of 33.6 kg/m^2 that would be classified as obese, and a mean initial daily caloric intake of 1804 kilocalories. The high compliance to the intervention demonstrates our intervention may have an impact on the lifestyle behavior of the breast cancer survivors. The exercise intervention was designed such that the participants engage to a progressive training session of one hour each, making 120 minutes of exercise per week. The first two weeks consisted of exercises at light to moderate intensity. The following eight weeks consisted of exercises at moderate to vigorous intensity. Despite not reaching the minimum requirement of 150 minutes per week of physical activity at moderate intensity or equivalent amount of 75 minutes at vigorous intensity, the breast cancer survivors in our study significantly decreased BMI, body weight, and waist circumference, all of which being risk factors of cardiovascular and metabolic disease and co-morbidities. Having the training sessions supervised by a qualified exercise professional, receiving dietary counselling from a registered dietician, and receiving prepared meals on a weekly basis are promising strategies to improve the lifestyle behavior of breast cancer survivors who are sedentary and had a BMI greater than 24.9 kg/m^2. The degree to which the exercise and the nutritional intervention has an impact on the lifestyle behavior of the breast cancer survivors is not confirmed as we did not include a control group. A recent weight loss intervention involving meal replacement and home-based exercise did not demonstrate an improvement of the outcome of lymphedema. Although safe, the randomized control trial confirms the need for a facility-based exercise program for greater benefits specifically for lymphedema (Schmitz et al., 2019). The American College of Sports Medicine (ACSM) also suggests that the preferred setting for exercise for persons with cancer is a supervised program under the direction of a fitness professional (American College of Sports Medicine et al., 2016)

With regards to our primary outcome, we hypothesized that a combination of exercise and nutrition would decrease body weight by 5-7% after 22 weeks. A weight loss greater than or equal to 5% reduces the incidence of breast cancer (Pan et al., 2019). Our preliminary results demonstrate the effect of 10 weeks of supervised bi-weekly training sessions, nutrition counselling, and intake of prepared meals targeted for breast cancer survivors. The 10-week intervention demonstrated a significant decrease in body weight (p=0.007) in breast cancer survivors, with a mean change of -2.7%. Comparatively, the WISER study combined a 20-week meal replacements and 52 weeks of home-based exercise program including bi-weekly resistance training and 180 minutes of walking per week, and reported a mean change of body weight of -8.06% in the combined group (Schmitz et al., 2019). Although our study followed a similar intervention plan, our results are only reflected by a 10-week intervention of prepared meals and bi-weekly training sessions. Although a decrease of 5-7% of body weight over the 22-week of intervention was hypothesized, 6 of the 19 participants from our study achieved the clinical meaningful weight loss of at least 5% of baseline body weight after only 10 weeks (Figure 1). Comparatively, the Stepping STONE study assessed 22 black breast cancer survivors, in which 10 participants received nutrition education, exercise session, and survivor-led motivational interviewing phone sessions for 12 weeks (Sheppard et al., 2016). The Stepping STONE study reported an overall adherence of 70% and despite the aim of 5% weight loss, the mean weight loss was 0.8% (Sheppard et al., 2016).

While a weight reduction of 5% is considered clinically meaningful, a weight loss at a rate of 0.5-1 kilograms per week is recommended, which signifies a loss of 5-10 kilograms of body weight is expected at week 10 of our study. Our study demonstrates that 64% of our participants reached the target weight loss. Of the breast cancer survivors who achieved the suggested weight loss of 5-10 kilograms at week 10, 71% have BCRL.

Management of body weight may be affected by several factors that are out of our control, including treatment and medications. Although tamoxifen is widely thought to be responsible for weight gain in breast cancer survivors, there is no evidence supporting this statement. A study by Demark-Wahnefried reports that patients undergoing chemotherapy tends to gain more body weight compared to patients receiving localized therapy alone (Demark-Wahnefried et al., 2012). In our study sample, 79% of our participants had chemotherapy. Other factors affecting management of body weight include level of stress, quality of sleep, the cultural background of the participants, and environmental factors.

The risk of development of breast cancer differs among premenopausal women and postmenopausal women. Although weight gain is not recommended, women with BMI greater than 24.9 kg/m^2 are reported to have a 20-40% lower risk of breast cancer (Schoemaker et al., 2018). The mechanism of the protective effect from a high BMI in premenopausal women is still unknown (Schoemaker et al., 2018). On the other hand, an increase of 5 kg/m^2 after menopause is associated with a 2% increase risk of breast cancer (Liu et al., 2018). Our study involves postmenopausal women and a significant decrease in BMI was observed. The management of BMI is a modifiable factor that reduces the risk of breast cancer recurrence in postmenopausal women, as there is a link between higher BMI and onset of hormone receptor-positive breast cancer (Dignam, 2003). A greater reduction in BMI is associated with positive health outcomes by reducing the risk of developing cardiovascular and metabolic diseases. Although the BMI is a measure of the body fat, the proportion of fat mass contributing to the body weight differs among women with the same BMI. The amount of fat tissue may be the link between the high BMI and risk of breast cancer.

A significant reduction in waist circumference was also demonstrated. The circumference of the waist is an indicator of visceral fat and is associated with cardiovascular and metabolic diseases and co-morbidities. The visceral fat is a clinical marker of insulin resistance and metabolic syndrome (Ravasco, 2010). An excess amount of insulin circulating in the blood reduces level of sex hormone binding globulin (SHBG). SHBG is a glycoprotein that binds to androgens and estrogens, and therefore plays a role in controlling estradiol. A reduction in SHBG increases circulating estradiol and thereby increases the risk of developing breast cancer (Key et al., 2001). The increase of the adipose tissue in the body occurs through hyperplasia and hypertrophy of the adipocyte, which are induced through an excess amount of caloric intake or lower caloric expenditure. The excess amount of adipose tissue in breast cancer survivors may increase the risk of cancer recurrence, as the adipose tissue produces hormones including estrogen, leptin, and pro-inflammatory cytokines, all of which may be contributing to the development of cancer. The binding of the estrogen with the estrogen receptor in the breast cell induces the growth of the breast cell. The leptin increases the development and progression of the growth of the tumor by binding on the transmembrane leptin receptor, which increases the cell proliferation through a signaling pathway (Andò et al., 2019). The pro-inflammatory cytokines are proteins that regulate the microenvironment of the inflammatory tumor, stimulating the proliferation and invasion of the cancer cell (Nicolini et al., 2006). Thus, inflammation induced by the excess of adipose tissue may be the physiological connection between obesity and the development of breast cancer. A non-randomized control trial compared the effect of low carbohydrate and low fat diet by providing a structured diet plan intervention over a 6-month period and reported a significant decrease in body weight (12.5%), body fat (27.5%), waist circumference (9.5%), and hip circumference (7.8%), and decrease in fat free mass (1.3%) (Thompson et al., 2015).

An increase in fat free mass and a decrease in fat mass is recommended to minimize the adverse effects from a body composition high in fat mass. Increase in fat free mass and decrease in fat mass can be achieved through regular resistance training, at minimum two times per week. Resistance training is widely known to increase fat free mass and improving and maintaining muscular strength. While resistance training improves the composition of the body, the intake of aromatase inhibitor such as anastrozole may affect the body density and its capacity to maintain lean mass. Despite the contradicatory effect on body composition between resistance training and aromatase inhibitors, the Hormones and Physical Exercise (HOPE) study demonstrated an increase in fat free mass and decrease in percentage of fat mass in breast cancer survivors taking aromatase inhibitors (Thomas et al., 2017). Qualified exercise professionals supervised the training sessions during the first 10 week of our study with the intention to incorporate progressive overload while ensuring the safety of the exercise performed. Progression overload intends to add gradual stress on the body to ensure improvement in fitness (Figure 2).

Despite the progressive training volume and a significant increase in training volume (p=0.001), our results demonstrate a significant decrease in absolute fat free mass (p=0.027) along with a non-significant decrease in absolute fat mass (p=0.124). Although the change in muscle mass is not measured, the signicant decrease in fat free mass may be attributable to the significant decrease in total body water. The results suggests that the body weight loss observed in our study is reflected by the significant decrease in total body water and statistically trending decrease in absolute fat free mass. The 6-month telephone-delivered behavioral weight loss intervention from the Living Well after Breast Cancer pilot trial demonstrated similar results, in which a decrease in fat mass and fat free mass measured from the bioimpedance spectroscopy resulted with a reduction in body weight (Reeves et al., 2017). Fat free mass is expected to decrease with a reduction in body weight (Heymsfield et al., 2014). The mean age of our participants is 62 years old and 45% takes tamoxifen and aromatase inhibitors, both of which are risk factors for loss of bone density. Despite the decrease in absolute fat free mass observed from our study, the relative fat free mass was maintained. Although an increase in relative fat free mass is recommended, the maintenance of relative fat free mass along with a decrease in body weight is a favorable outcome as long as the relative fat free mass does not decrease.

With regards to the water content of the body, hydration is important to maintain the control of cellular protein turnover that may affect oncotic pressure. The normal range of total body water is 55-60% in men and 50-55% in women to maintain overall health (Stefani, Laura et al., 2017). The ratio of intracellular fluid and extracellular fluid of 3:2 is recommended in cancer patients to maintain overall physiologic and cognitive functions (Stefani et al., 2017). Our results demonstrate that the significant reduction in body weight resulted in a significant reduction in absolute total body water content. The relative total body content did not significantly change, although the values are below the recommended level. Our results also demonstrate that the ratio of intracellular fluid and extracellular fluid is 2.7:2. The ratio of our study suggests that that there is a greater amount of extracellular fluid. Although 58% of the participants have BCRL, the ratio of 2.7:2 remains the same when comparing the ratio between BCRL and BC without lymphedema subgroup. The exercise and dietary intervention seem to not affect the level of extracellular fluid in the body.

Our study observed the dietary changes influenced by the nutritional counselling, the provided prepared meals, and the cooking classes. The present preliminary results reflect the changes induced by the nutritional counselling and provided prepared meals only, because the cooking classes were given after week 10. Despite an average reduction in daily caloric intake of 475 kilocalories from baseline to week 10, the changes showed a statistical trend ($p=0.072$). The statistical trending decrease in daily caloric intake suggest that the prepared meals and the nutritional counselling may have a beneficial effect on weight loss, as 74% of the breast cancer survivors achieved a clinical meaningful weight loss after 10 weeks. Interestingly, the caloric intake of the participants with BCRL significantly decreased from baseline to week 10, suggesting that there may be a learning effect from the nutritional counselling and the provided prepared meals on the dietary habit of the participants with BCRL.

A dose response relationship between dietary fat and weight loss indicates that dietary fat plays a role in management of body weight. A reduction of 10% of dietary fat induce a weight loss of 4-5kg in individuals with an initial BMI of 30 kg/m^2 (Institute of Medicine, 2003). The mean initial BMI of our population is 33.6 kg/m^2. Weight loss achieved through a diet composed of 20-30% of energy from fat is more achievable than a severely restricted low-fat diet with energy from fat contributing to 20% of the total energy intake (Kris-Etherton et al., 2002). The results from our study show a significant drop of energy from dietary fat from 39% at baseline to 29.2% at week 10 ($p=0.027$), along with a significant weight reduction of 2.4kg ($p=0.007$). Similar results are observed from the randomized control trial that included a low-fat diet of 20% of total energy intake through dietary counselling (Shaw et al., 2007a). The randomized control trial reported a significant weight reduction of 2.9kg after 24 weeks of intervention ($p=0.006$), along with a significant reduction in energy intake from dietary fat of 26% ($p=0.001$) (Shaw et al., 2007a). The link between dietary fat and risk of breast cancer is inconclusive, with several studies demonstrating contradicting results, ranging from positive relation to no association (Ravasco, 2010). Studies report that dietary fat, specifically saturated fat, increases the production of estrogen, a main determinant for risk of breast cancer (Ravasco, 2010).

The combination of our dietary and exercise intervention shows a significant reduction of systolic blood pressure by week 10. Similar results are observed from the ENERGY trial study, which aimed to reduce body weight of breast cancer survivors with a BMI between 25 and 48 kg/m^2 through group-based cognitive-behavioral weight loss program. The program was designed to reduce energy intake relative to expenditure and increase physical activity. In addition to demonstrating a significant weight loss, the ENERGY trial study demonstrated a significant decrease in systolic blood pressure at 6, 12, 18, and 24 months (Rock et al., 2015). The combination of a dietary and exercise intervention seems to benefit the reduction of blood pressure; although, it would be interesting to determine whether the exercise or the nutrition has a more prominent effect on the systolic blood pressure. Although our main focus was not to reduce the blood pressure, our protocol of prepared meals follows the similar idea of the Dietary Approaches to Stop Hypertension (DASH) diet. The DASH diet aims to reduce blood pressure by recommending a diet that is rich in fruits, vegetables, and low-fat dairy products, and lower saturated fat and cholesterol. Our prepared meals and nutrition counselling were specifically targeted to prevent recurrence of breast cancer by reducing body weight. We encourage higher intake in fruits and vegetables, omega-3, fibers, and protein. Comparatively, the Women's Healthy Eating and Living (WHEL) study demonstrated that following a dietary group intervention, participants with history of breast cancer within the previous four years significantly increased intake of fruits by 25%, vegetables by 65%, and fibers by 30% and decreased intake of fat by 13%, but no significant weight loss was observed, with one kilogram difference in average weight at any time point of the study (Pierce et al., 2007).

A higher intake of omega-3 is recommended for breast cancer survivors as studies demonstrate a protective effect to prevent the recurrence of breast cancer (Fabian et al., 2015). The omega-3 has properties capable of generating bioactive lipid mediators that modulate inflammation, hence delaying the development of breast cancer (Spencer et al., 2009). Although the recommended daily intake of omega-3 for women is 1.1g, the recommendation of daily intake of omega-3 is higher in breast cancer survivors. Prior to starting the study, the participants consumed 172.6% of the recommended daily allowance of omega-3. Despite increasing the awareness of increasing omega-3 in the daily meals, the breast cancer survivors from our study reduced their daily intake by 0.94g of omega-3. The reduction in omega-3 intake may be reflected by the reduction in daily food intake of the participants. Despite a reduction in daily intake of omega-3, the participants consumed omega-3 130% more than the recommended intake at week 10.

All of our participants are breast cancer survivors with 58% having BCRL, and none demonstrated worsening outcomes regarding lymphedema during the 10-week study. The results obtained from the BCRL subgroup demonstrated that 55% of the women with BCRL achieved the clinical meaningful weight loss of 5%. Patients with BCRL are recommended to maintain a normal BMI because obesity may be associated with inflammation and worsening of lymphedema (Borman, 2018). Several factors may contribute to the increase of volume of the arm. The complications occurring after the treatment may affect the efficiency of the extrinsic force from the skeletal muscle contractions and the intrinsic force from the active pumping of the collecting vessel network, all of which help move the lymph against a hydrostatic pressure gradient (Scallan et al., 2016). Excess amount of body fat may also increase the volume of the arm. The excess of subcutaneous fat may disrupt the deep lymphatic channels, which affect the functions of the lymphatic system and thus, creating more inflammation. Our second hypothesis was that the women with BCRL would significantly decrease the arm volume of the affected side with the combined exercise and dietary intervention. In our study, the volume of the affected arm and the unaffected arm reduced significantly, with a mean difference of -200.0 mL (-6.4%, p=0.031) and -185.5 mL (-6.8%, p=0.017), respectively. The interlimb volume difference did not show a significant difference, which agrees with several studies reporting that exercise do not worsen the lymphedema symptoms. A study demonstrated that despite no change in volume of the arm, there was an improvement in composition of the arm with exercise alone (Zhang et al., 2017). The dual-energy x-ray absorptiometry revealed that after 12-months of resistance training, a greater lean mass and body mass density, and a decrease in fat percentage of the affected arm were observed (Zhang et al., 2017).

A pilot study recruited 21 participants with BCRL who were randomized into a weight-reduction group (n=11) who which received dietary advice to reduce calorie intake by 1000-1200 kilocalories and control group (n=10) who did not receive a dietary intervention. The pilot study demonstrated a significant correlation exists (r=0.513, p=0.017) between weight loss and reduction in volume of the affected arm through a 12-week intervention of individualized dietary advice (Shaw et al., 2007b). The pilot study reported a significant difference in body weight and BMI, with a mean decrease of -3.3kg and -1.3 kg/m^2, respectively after the 12-week of dietary intervention. Similarly, our results indicate a significant loss in body weight of -2.3kg and a significant decrease in BMI of -0.9 kg/m^2 in women with BCRL. The Pearson correlation test showed a positive statistically significant correlation between percent arm volume reduction and body weight (r=0.595, p=0.054). The main difference between our study and Shaw's pilot study is that we recommended a calorie deficit of 500 kilocalories instead of 1000-1200 kilocalories, and we added the fitness component with the idea that a greater effect on body weight and BMI could occur. Although a reduction in arm volume was observed in our study, it lacks information about the tissue composition of the arm. Different mechanisms may explain the reduction in volume of the arm, including a reduction in excess amount of fluid, or that the anti-inflammatory properties of the diet may have reduced the inflammation caused by the lymphedema. Although the bioelectrical impedance analysis used to assess the body composition do not focus on the composition of the tissue of the arm, our results demonstrate a significant decrease in total body water in women with BCRL (p=0.048), but the total body extracellular fluid was not significantly different (p=0.31), suggesting that the accumulation of fluid commonly that resulted to lymphedema is not affected by the intervention. Another possible mechanism that may result in a decrease in arm volume is the loss of localized subcutaneous fat mass in the affected and unaffected arm. The absolute fat mass in women with BCRL, although not specifically reflected by the composition of the affected arm, was not significantly different (p=0.448). A future study examining the effect of supervised training session and dietary intervention on the composition of the tissue of the arm would provide additional insight on what caused the volume of the arm to decrease.

Conclusion

As weight gain is a common risk factor in breast cancer survivors and as survival rates keep on increasing, management of the modifiable factors are important to maintain good quality of life. Chronic fatigue, fear of cancer recurrence, body image issue, and depression, are examples of barriers affecting the feasibility of breast cancer survivors to engage in a healthier lifestyle. As such, breast cancer survivors are prone to a sedentary lifestyle and poor eating habit. Our findings support the efficacy of supervised training sessions combined with prepared meals for breast cancer survivors. Our results demonstrate that breast cancer survivors who had a sedentary lifestyle and a BMI greater than 24.9 kg/m^2 were able to adhere to progressive training program of two sessions of 60 minutes per week and to receive prepared meals. We hypothesized that our study would generate a clinical meaningful five to seven percent decrease in body weight after the 22-week intervention. Our preliminary results demonstrate the effect over the 10 weeks. After 10-weeks of the intervention, our participants significantly loss body weight, with the mean change of -2.7%, along with a significant decrease in volume of the arm. The data of the 22-week intervention would provide more information about how the supervised training sessions and prepared meals may impact the behavioral changes in breast cancer survivors without in-person interactions, and its impact on the weight and body composition.

A randomized control trial with larger sample size would provide more insight on the effect of the exercise and the prepared meals individually on the body weight and volume of the arm of breast cancer survivors. Additionally, as women with BCRL significantly decreased the volume of the affected arm, it would be interesting to evaluate the composition of the affected arm.

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Chapter III

Limitations and conclusions

Our study presents with several limitations and challenges. Although our study is a pilot study, the size of our sample is small, which generates small statistic power. Due to recruitment challenges and feasibility uncertainty, our sample was not randomized, and all participants received the same intervention.

The lack of control group prevents us from explaining what may have caused the observed results. The results observed from this single-group pilot study is reflected by the combination of both exercise and dietary interventions. No information is provided from our study with regards to which of the two interventions has the most prominent effect on the weight and body composition of the breast cancer survivors. A randomized control trial compared the effect of lifestyle change interventions in overweight-to-obese post-menopausal women. The study compared the effects of aerobic exercise (e.g., five days per week at moderate-to-vigorous intensity), and dietary manipulation and counseling on the body weight and body composition. The results obtained after 12 months of intervention demonstrated that the three lifestyle change interventions led to a significant weight loss, with a greater effect from the combined exercise and dietary interventions (Foster-Schubert et al., 2011).

Although our study was not focusing on the BCRL, body fat percentage assessment on the arm would give us more insight on how the intervention affects the composition of the arm, in addition to observing a significant difference in volume of the arm. We did not control for the time of breast cancer diagnosis, and recruited all women with a history of breast cancer.

Concluding remarks

To conclude, our study supports the efficacy of supervised training sessions and prepared meals for breast cancer survivors. Our results also support the safety of an exercise intervention at vigorous intensity in breast cancer survivors. Despite starting the study with a history of sedentary lifestyle and a BMI greater or equal to 25 kg/m^2, our study demonstrate that two training sessions of 60 minutes each week is a feasible starting point to increase the level of physical activity in breast cancer survivors and to decrease body weight and volume of the arms. Providing the prepared meals contributed to improved eating habit as our participants decreased dietary fat intake. Combining supervised training sessions and prepared meals demonstrate promising benefits for breast cancer survivors.

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Appendix A : 22-weeks progressive training program

Exercise Protocol			
Week	Exercise	Time /Set	Intensity
1 (Supervised)	Upright bicycle	5 minutes	25%HRR (warm up)
		10 minutes	40%HRR (training phase)
		5 minutes	25%HRR (cool down)
	Sit to stand	2x10	10RM
	Chest press with tubing band		
	Low row with tubing band		
	Biceps curl with tubing band		
	Triceps extension with tubing band		
	Single leg stance	2x15 seconds (each leg)	
	Modified dead bug (just the legs)	2x10	
	Stretch (chest/biceps, walking hands seated cat cow,	1x15seconds each muscles	

	triceps, hamstrings, quadriceps)		
2 (Supervised)	Upright bicycle	5 minutes	25%HRR (warm up)
		15 minutes	40%HRR (training phase)
		5 minutes	25%HRR (cool down)
	Sit to stand	2x10	10RM
	Chest press with tubing band		
	Low row with tubing band		
	Biceps curl with tubing band		
	Triceps extension with tubing band		
	Single leg stance	2x15 seconds (each leg)	
	Modified dead bug (just the legs)	2x10	
	Stretch (chest/biceps, walking hands seated cat cow, triceps, hamstrings, quadriceps)	1x15seconds each muscles	
3 (Supervised)	Upright bicycle	5 minutes	25%HRR (warm up)
		20 minutes	40%HRR (training phase)

		5 minutes	25%HRR (cool down)
	Leg press	2x10	10RM
	Chest press		
	Low row		
	Biceps curl with dumbbells		
	Triceps extension with dumbbells		
	Single leg stance	2x15 seconds (each leg)	
	Modified dead bug (just the legs)	2x10	
	Stretch (chest/biceps, walking hands seated cat cow, triceps, hamstrings, quadriceps)	1x15seconds each muscles	
4 (Supervised)	Upright bicycle	5 minutes	30-40%HRR (warm up)
		20 minutes	50%HRR (training phase)
		5 minutes	30-40%HRR (cool down)
	Leg press	2x10	10RM
	Chest press		
	Low row		
	Biceps curl with dumbbells		

	Triceps extension with dumbbells		
	Single leg stance	2x15 seconds (each leg)	
	Modified dead bug (just the legs)	2x10	
	Stretch (chest/biceps, walking hands seated cat cow, triceps, hamstrings, quadriceps)	1x15seconds each muscles	
5-10 (Supervised)	Upright bicycle	5 minutes	30-40%HRR (warm up)
		20 minutes	60%HRR (training phase)
		5 minutes	30-40%HRR (cool down)
	Leg press	2x10	10RM
	Chest press		
	Low row		
	Biceps curl with dumbbells		
	Triceps extension with dumbbells		
	3 ways touch on balance pad	2x10 (each leg)	
	Dead bug	2x10	
	Stretch (chest/biceps,	1x15seconds each muscles	

	walking hands seated cat cow, triceps, hamstrings, quadriceps)		
11-22 (Unsupervised)	Upright bicycle	5 minutes	30-40%HRR (warm up)
		20 minutes	60%HRR (training phase)
		5 minutes	30-40%HRR (cool down)
	Leg press	2x10	10RM
	Chest press		
	Low row		
	Biceps curl with dumbbells		
	Triceps extension with dumbbells		
	3 ways touch on balance pad	2x10 (each leg)	
	Dead bug	2x10	
	Stretch (chest/biceps, walking hands seated cat cow, triceps, hamstrings, quadriceps)	1x15seconds each muscles	

Appendix B: Details of the menu

#1 Breakfast Recipes / Items	Key nutrition facts	per portion (recipes)	per meal	Allergens CONTAINS:	MAY CONTAIN:
Banana muffin (1 muffin)	Kcal	152	301		
1 cup yogurt	Carb (g)	22	33	Wheat, eggs	*Traces of soy, nuts*
	Fibre (g)	3	3		
	Protein (g)	3	12		
	Fat (g)	6	14		
	omega-3 (g)	0.34	0.41		
Cinnamon Oatmeal with 1 Tablespoon ground flaxseed (1/2 cup ~125 ml)	Kcal	100	137		Traces of wheat, nuts, soy
	Carb (g)	17	19		
	Fibre (g)	3	5		
	Protein (g)	3	5		
	Fat (g)	2	5		
	omega-3 (g)	1.64	1.64		
Kasha granola bar	Kcal	160	190	Egg, dairy	Traces of wheat, nuts, soy
1 Plum	Carb (g)	27	34		
	Fibre (g)	4	5		
	Protein (g)	5	6		
	Fat (g)	4	4		
	omega-3 (g)	0.49	0.49		
Pumpkin muffin	Kcal	160	218	Wheat, eggs	Traces of wheat, nuts, soy

(1 muffin) ***1 fruit of your choice***	Carb (g)	21	36		
	Fibre (g)	2	5		
	Protein (g)	3	4		
	Fat (g)	7	8		
	omega-3 (g)	1.15	1.15		
Apple Cinammon breakfast risotto	Kcal	130	400	Dairy	Traces of wheat, nuts, soy
(take 1 cup - 2 portions) ***1 cup yogurt***	Carb (g)	28	67.5		
	Fibre (g)	2	3		
	Protein (g)	2	12		
	Fat (g)	1	10		
	omega-3 (g)	0.06	0.19		

#1 Recipes	**For balance, pair at home with:**	Canada's food guide	Key nutrition facts			Allergens	
				per portion (recipes)	per meal	*CONTAINS:*	*MAY CONTAIN:*
Quinoa Salad	**250 mL milk or kefir, orange slices**		Kcal	203	576		
(take 2 portions of ¾ cup = 1 ½ cups)		Grain	Carb (g)	38	103.5		
		F/V	Fibre (g)	5	13	*none*	*Wheat, sulfites*
	Water (1-2 cups ~ 250-500 ml)	Milk/alt	Protein (g)	7	24		
			Fat (g)	3	9		
			omega-3 (g)	0.3	0.3		
Buckwheat pilaf with vegetable medley and turkey bacon	**250 mL yogourt or kefir**	Mt/alt	Kcal	230	358		
(take 1 portion = 1 cup)		Grain	Carb (g)	34	53	*none*	*Nuts, sesame, mustard, soya and wheat*
		F/V	Fibre (g)	3	3		
	Water (1-2 cups ~ 250-500 ml)	Milk/alt	Protein (g)	9	21		
			Fat (g)	8	8		

			omega-3 (g)	0.35	0.35		
Orange spice zucchini muffins	**Veggie sticks, apple or orange**	Mt/alt	Kcal	140	565		
(take 2 muffins = 2 portions)	**50 g cheddar cheese**	Grain	Carb (g)	18	59		
		F/V	Fibre (g)	2	9	*Wheat, eggs, milk*	*Nuts, peanuts, sesame, mustard, soya*
	Water (1-2 cups ~ 250-500 ml)	Milk/alt	Protein (g)	3	19		
			Fat (g)	6	29		
			omega-3 (g)	0.12	0.31		
Traditional mole with chickpeas and rice	**Fresh veggies**	Mt/alt	Kcal	280	448		
(take 1 cup mole + 2/3 cup rice = 1 portion)	**250 mL milk or yogurt**	Grain	Carb (g)	47	60		
		F/V	Fibre (g)	10	11	*none*	*Sesame mustard, soya, wheat, milk ingredients*
	Water (1-2 cups ~ 250-500 ml)	Milk/alt	Protein (g)	11	30		
			Fat (g)	6	10		
			omega-3 (g)	0.09	0.09		
Vegetarian chili	**Whole grain bread, 1-2 slices**	Mt/alt	Kcal	80	507		
(take 2 portions of ½ cup = 1 cup)	**50 g mozzarella cheese**	Grain	Carb (g)	15	54		
		F/V	Fibre (g)	3	8	*none*	*Sesame, mustard, soya and wheat*
	Water (1-2 cups ~ 250-500 ml)	Milk/alt	Protein (g)	4	22		
			Fat (g)	0.5	19		
			omega-3 (g)	0.13	0.31		

#2 Breakfast Recipes / Items	Key nutrition facts per portion (recipes)		per meal	Allergens CONTAINS:	MAY CONTAIN:
Cornbread muffin	Kcal	100	358	Wheat, eggs	Traces of
1 muffin	Carb (g)	20	35	dairy	soy and nuts
50 g cheese	Fibre (g)	2	2		
125 ml grapes (seedless)	Protein (g)	3	16		
	Fat (g)	1.5	18		
	omega-3 (g)	0.02	0.21		
Cranberry-orange rice pudding ***(Take 1 cup=2 portions)***	Kcal	120	312	Dairy	Traces of wheat soy
	Carb (g)	25	69		and nuts
1 Apple	Fibre (g)	0	3		
	Protein (g)	4	8		
	Fat (g)	0.5	1.5		
	omega-3 (g)	0.01	0.02		
Raspberry Bran Muffin	Kcal	120	272	Wheat, eggs	Traces of wheat, soy
Take 1portion	Carb (g)	15	27	dairy	and nuts
1 cup yogurt	Fibre (g)	2	2		
	Protein (g)	3	11		
	Fat (g)	6	14		
	omega-3 (g)	0.72	0.79		
Blueberry Smoothie ***(Take 1/2 cup=1 portion)*** **50 g cheese**	Kcal	60	260	Dairy	Traces of wheat
	Carb (g)	14	15		
	Fibre (g)	2	2		
	Protein (g)	1	13		
	Fat (g)	0	17		
	omega-3 (g)	0	0.18		

Banana muffin (1 muffin)	Kcal	152	301		
1 cup yogurt	Carb (g)	22	33	Wheat, eggs	*Traces of soy, nuts*
	Fibre (g)	3	3		
	Protein (g)	3	12		
	Fat (g)	6	14		
	omega-3 (g)	0.34	0.41		

#2 Recipes	For balance, pair at home with:	Canada's food guide	Key nutrition facts			Allergens	
				per portion (recipes)	per meal	*CONTAINS:*	*MAY CONTAIN:*
Lentil shepherd's pie ***(take 2 pieces = 2 portions)***	**250 mL milk or yogurt, orange slices**	Mt/alt	Kcal	180	510	*Milk, soy*	*Sesame seeds, Mustard Seeds, Wheat*
		Grain	Carb (g)	26	63		
		F/V	Fibre (g)	5	10		
		Milk/alt	Protein (g)	6	21		
			Fat (g)	6	20		
			omega-3 (g)	0.33	0.4		
Raspberry chicken stir fry & Lentil rice recipe ***(take ¾ cup chicken breast + 1 cup frozen veggies + ¾ cup rice and lentils)***	**Ok as is**	Mt/alt	Kcal	455	455	*none*	*wheat*
		Grain	Carb (g)	75	75		
		F/V	Fibre (g)	13	13		
			Protein (g)	34	34		
			Fat (g)	2.5	2.5		
			omega-3 (g)	0.18	0.18		
Hummus		Mt/alt	Kcal	70	542	*Sesame, milk*	*none*

(take ¾ cup = 6 portions)	**Veggie sticks, sliced whole wheat pita 250 mL milk or yogurt**	Grain	Carb (g)	5	42		
		F/V	Fibre (g)	1	6		
		Milk/alt	Protein (g)	2	20		
			Fat (g)	3.5	26		
			omega-3 (g)	2.07	2.08		
Couscous salad with navy beans	**Ok as is**	Mt/alt	Kcal	165	330	*milk products, sulphites, soya, wheat*	*peanuts, tree nuts, soy ingredients, wheat*
(take 1 cup = 2 portions)		Grain	Carb (g)	27	54		
		F/V	Fibre (g)	3	6		
			Protein (g)	8	16		
			Fat (g)	4	8		
			omega-3 (g)	0.12	0.24		
Carrot ginger soup with lentils	**Whole grain bread, 1-2 slices**	Mt/alt	Kcal	140	621	*none*	*wheat*
(take 2 cups = 2 portions)	**50 g cheese**	Grain	Carb (g)	25	72		
		F/V	Fibre (g)	5	14		
		Milk/alt	Protein (g)	7	34		
			Fat (g)	2.5	23		
			omega-3 (g)	0.44	0.73		

#3 Breakfast Recipes / Items	Key nutrition facts			Allergens	
	per portion (recipes)		per meal	*CONTAINS:*	*MAY CONTAIN:*
Cinnamon Oatmeal with 1 Tablespoon	Kcal	100	137		Traces of wheat, nuts, soy

ground flaxseed (1/2 cup ~125 ml)	Carb (g)	17	19		
	Fibre (g)	3	5		
	Protein (g)	3	5		
	Fat (g)	2	5		
	omega-3 (g)	1.64	1.64		
Kasha granola bar	Kcal	160	190	Egg, dairy	Traces of wheat, nuts, soy
1 Plum	Carb (g)	27	34		
	Fibre (g)	4	5		
	Protein (g)	5	6		
	Fat (g)	4	4		
	omega-3 (g)	0.49	0.49		
Pumpkin muffin	Kcal	160	218	Wheat, eggs	Traces of wheat, nuts, soy
(1 muffin)	Carb (g)	21	36		
1 fruit of your choice	Fibre (g)	2	5		
	Protein (g)	3	4		
	Fat (g)	7	8		
	omega-3 (g)	1.15	1.15		
Apple Cinammon breakfast risotto ***(take 1 cup - 2 portions)***	Kcal	130	400	Dairy	Traces of wheat, nuts, soy
	Carb (g)	28	67.5		
1 cup yogurt	Fibre (g)	2	3		
	Protein (g)	2	12		
	Fat (g)	1	10		
	omega-3 (g)	0.06	0.19		
Cornbread muffin	Kcal	100	358	Wheat, eggs	Traces of
1 muffin	Carb (g)	20	35	dairy	soy and nuts
50 g cheese	Fibre (g)	2	2		

125 ml grapes (seedless)	Protein (g)	3	16
	Fat (g)	1.5	18
	omega-3 (g)	0.02	0.21

#3 Recipes	**For balance, pair at home with:**	Canada's food guide	Key nutrition facts	per portion (recipes)	per meal	Allergens CONTAINS:	MAY CONTAIN:
Indian-style apricot chicken & Lentil rice recipe *(take 1 piece chicken + 1/2 cup apricot sauce + ¾ cup rice and lentils)*	**baby carrots**	Mt/alt	Kcal	370	370	*none*	*none*
		Grain	Carb (g)	56	56		
		F/V	Fibre (g)	7	7		
			Protein (g)	22	22		
			Fat (g)	6	6		
			omega-3 (g)	0.11	0.11		
Quinoa chickpea salad *(take 1 cup = 2 portions)*	**Ok as is**	Mt/alt	Kcal	363	424	*Milk ingredients, soya, sulphites*	*peanuts, tree nuts, soy ingredients, wheat*
		Grain	Carb (g)	54	69.45		
		F/V	Fibre (g)	4.54	6.88		
1 orange		Milk/alt	Protein (g)	13.31	14.54		
			Fat (g)	11.24	11.4		
			omega-3 (g)	0.09	0.18		
Vegetable chickpea curry & Lemon rice *(take ¾ cup curry + 2/3 cup rice)*	**1 apple**	Mt/alt	Kcal	289	362.56	*mustard*	*peanuts*
		Grain	Carb (g)	47.95	67.05		
		F/V	Fibre (g)	6.52	9.15		
		Milk/alt	Protein (g)	8.53	8.88		
			Fat (g)	7.83	7.83		
			omega-3 (g)	2.44	2.44		

Black bean burrito farce *(take 1 cup)*	**Tortilla (10" or 70 g) or 2 slices whole grain bread**	Mt/alt Grain F/V Milk/alt	Kcal Carb (g) Fibre (g) Protein (g) Fat (g) omega-3 (g)	370 61 28 16 3.5 0.31	370 61 28 16 3.5 0.35	*milk*	*Sesame seeds*
Curried zucchini soup with lentils ***(take 1 cup)***	**low sodium crackers (e.g. Ryvita) or sliced whole wheat pita**	Mt/alt Grain F/V	Kcal Carb (g) Fibre (g) Protein (g) Fat (g) omega-3 (g)	160 29 6 8 2.5 0.29	330 64 11 14 4.5 0.32	*none*	*none*

#4 Breakfast Recipes / Items	Key nutrition facts			Allergens	
	per portion (recipes)		per meal	*CONTAINS:*	*MAY CONTAIN:*
Cranberry-orange rice pudding ***(Take 1 cup=2 portions)*** **1 Apple**	Kcal Carb (g) Fibre (g) Protein (g) Fat (g) omega-3 (g)	120 25 0 4 0.5 0.01	312 69 3 8 1.5 0.02	Dairy	Traces of wheat soy and nuts
Raspberry Bran Muffin ***Take 1portion*** **1 cup yogurt**	Kcal Carb (g) Fibre (g)	120 15 2	272 27 2	Wheat, eggs	Traces of wheat, soy

	Protein (g)	3	11		
	Fat (g)	6	14		
	omega-3 (g)	0.72	0.79		
Blueberry Smoothie *(Take 1/2 cup=1 portion)* **50 g cheese**	Kcal	60	260	Dairy	Traces of wheat
	Carb (g)	14	15		
	Fibre (g)	2	2		
	Protein (g)	1	13		
	Fat (g)	0	17		
	omega-3 (g)	0	0.18		
Banana muffin (1 muffin)	Kcal	152	301		
1 cup yogurt	Carb (g)	22	33	Wheat, eggs	*Traces of soy, nuts*
	Fibre (g)	3	3		
	Protein (g)	3	12		
	Fat (g)	6	14		
	omega-3 (g)	0.34	0.41		
	Kcal	140	339		
Orange spice zucchini muffins (take 1 muffins = 1 portion) 50 g of cheese	Carb (g)	18	18	Wheat, eggs, dairy	Traces of soy, nuts
	Fibre (g)	2	2		
	Protein (g)	3	16		
	Fat (g)	6	23		
	omega-3 (g)	0.34	0.52		

#4 Recipes	For balance, pair at home with:	Canada's food guide	Key nutrition facts	per portion (recipes)	per meal	Allergens CONTAINS:	MAY CONTAIN:
Wheat berry and apple salad (take 2 portions of ¾ cup = 1 ½ cups)	**250 ml yogurt or kefir**	Grain	Kcal	100	350	*Wheat*	*Sulphites*
		F/V	Carb (g)	17	45		
		Milk/alt	Fibre (g)	2	4		
			Protein (g)	2	13		
			Fat (g)	4	19		
			omega-3 (g)	0.65	0.71		
Buckwheat pilaf with vegetable medley and turkey bacon (take 1 portion = 1 cup)	**250 mL yogurt or kefir**	Mt/alt	Kcal	200	350	*none*	*Nuts, sesame, mustard, soya and wheat*
		Grain	Carb (g)	32	43		
		F/V	Fibre (g)	3	3		
		Milk/alt	Protein (g)	8	17		
			Fat (g)	7	15		
			omega-3 (g)	0.35	0.41		
Orange spice zucchini muffins (take 2 muffins = 2 portions)	**Veggie sticks, apple or orange 50 g cheddar cheese**	Mt/alt	Kcal	140	550	*Wheat, eggs, milk*	*Nuts, peanuts, sesame, mustard, soya*
		Grain	Carb (g)	18	56		
		F/V	Fibre (g)	2	7		
		Milk/alt	Protein (g)	3	18		
			Fat (g)	6	27		
			omega-3 (g)	0.11	0.31		
South East Asian inspired salmon and rice cakes (take 2 patties)	**Green salad, glass of milk**	Mt/alt	Kcal	360	460	*Fish, eggs*	
		Grain	Carb (g)	19	31		
			Fibre (g)	2	2		
			Protein (g)	30	38		

			Fat (g)	17	19		
			omega-3 (g)	2.07	2.08		
Pinto bean soup (take 1 portion = 1 cup)	**low sodium crackers (7 melba mini toast), 1/2 avocado and 50 g mozzarella cheese (1/4 cup)**	Mt/alt	Kcal	190	487	*none*	*Sesame, mustard, soya and wheat*
		Grain	Carb (g)	34	52		
		F/V	Fibre (g)	7	12		
		Milk/alt	Protein (g)	9	24		
			Fat (g)	3	23		
			omega-3 (g)	0.25	0.41		

#5 Breakfast Recipes / Items	Key nutrition facts			Allergens	
		per portion (recipes)	per meal	*CONTAINS:*	*MAY CONTAIN:*
Cinnamon Oatmeal with 1 Tablespoon ground flaxseed (1/2 cup ~125 ml)	Kcal	100	137		Traces of wheat, nuts, soy
	Carb (g)	17	19		
	Fibre (g)	3	5		
	Protein (g)	3	5		
	Fat (g)	2	5		
	omega-3 (g)	1.64	1.64		
Kasha granola bar ***1 Plum***	Kcal	160	190	Egg, dairy	Traces of wheat, nuts, soy
	Carb (g)	27	34		
	Fibre (g)	4	5		
	Protein (g)	5	6		
	Fat (g)	4	4		
	omega-3 (g)	0.49	0.49		
Pumpkin muffin ***(1 muffin)***	Kcal	160	218	Wheat, eggs	Traces of wheat, nuts, soy
	Carb (g)	21	36		

1 fruit of your choice	Fibre (g)	2	5		
	Protein (g)	3	4		
	Fat (g)	7	8		
	omega-3 (g)	1.15	1.15		
Apple Cinammon breakfast risotto (take 1 cup - 2 portions), 1 cup yogurt	Kcal	130	400	Dairy	Traces of wheat, nuts, soy
	Carb (g)	28	67.5		
	Fibre (g)	2	3		
	Protein (g)	2	12		
	Fat (g)	1	10		
	omega-3 (g)	0.06	0.19		
Cornbread muffin	Kcal	100	358	Wheat, eggs	Traces of
1 muffin	Carb (g)	20	35	dairy	soy and nuts
50 g cheese	Fibre (g)	2	2		
125 ml grapes (seedless)	Protein (g)	3	16		
	Fat (g)	1.5	18		
	omega-3 (g)	0.02	0.21		

#5 Recipes	For balance, pair at home with:	Canada's food guide	Key nutrition facts			Allergens	
				per portion (recipes)	per meal	*CONTAINS:*	*MAY CONTAIN:*
Lentil & BBQ corn salad with cilantro lime dressing	**Whole grain rice or bread**	Mt/alt	Kcal	260	496		
(take 1 cup)	**250 ml milk or yogurt**	Grain	Carb (g)	42	67	*none*	*Sulphites, nuts, soy or sesame*
		F/V	Fibre (g)	7	9		
		Milk/alt	Protein (g)	10	24		
			Fat (g)	9	18		
			omega-3 (g)	0.65	0.73		

Roasted rosemary potatoes & Roasted chicken with citrus (take 1 cup potato + 1 piece chicken)	**Cooked mixed vegetables**	Mt/alt	Kcal	273	391	*none*	*Sesame, mustard, soya and wheat*
		Grain	Carb (g)	22	46		
		F/V	Fibre (g)	2.5	7.5		
			Protein (g)	24	29		
			Fat (g)	10	10		
			omega-3 (g)	0.32	0.35		
Spinach tofu dip (take 1/3 cup = approx. 3 portions)	**Raw veggies, 1/2 whole wheat pita (6.5 inches/16.5 cm diameter)**	Mt/alt	Kcal	15	297	*Soya, sesame*	*Wheat*
		Grain	Carb (g)	1	36		
		F/V	Fibre (g)	0.4	5		
	250 mL milk or yogurt	Milk/alt	Protein (g)	1	15		
			Fat (g)	1	12		
			omega-3 (g)	0.04	0.12		
Vegetable chickpea curry & Lemon rice *(take ¾ cup curry + 2/3 cup rice)*	**Ok as is**	Mt/alt	Kcal	289	289	*mustard*	*peanuts*
		Grain	Carb (g)	47.95	47.95		
		F/V	Fibre (g)	6.52	6.52		
		Milk/alt	Protein (g)	8.53	8.53		
			Fat (g)	7.83	7.83		
			omega-3 (g)	2.44	2.44		
Carrot ginger soup with lentils *(take 2 cups = 2 portions)*	**Whole grain bread, 1 slice**	Mt/alt	Kcal	140	549	*none*	*wheat*
	50 g cheese	Grain	Carb (g)	25	61		
		F/V	Fibre (g)	5	12		
		Milk/alt	Protein (g)	7	30		
			Fat (g)	2.5	23		
			omega-3 (g)	0.44	0.68		

#6 Breakfast Recipes / Items	Key nutrition facts			Allergens	
		per portion (recipes)	per meal	*CONTAINS:*	*MAY CONTAIN:*
Raspberry Bran Muffin	Kcal	120	272	Wheat, eggs	Traces of wheat, soy
Take 1portion	Carb (g)	15	27		
1 cup yogurt	Fibre (g)	2	2		
	Protein (g)	3	11		
	Fat (g)	6	14		
	omega-3 (g)	0.72	0.79		
Cranberry-orange rice pudding	Kcal	120	312	Dairy	Traces of wheat soy
(Take 1 cup=2 portions)	Carb (g)	25	69		and nuts
1 Apple	Fibre (g)	0	3		
	Protein (g)	4	8		
	Fat (g)	0.5	1.5		
	omega-3 (g)	0.01	0.02		
Blueberry Smoothie *(Take 1/2 cup=1 portion)*	Kcal	60	260		
	Carb (g)	14	15		
50 g cheese	Fibre (g)	2	2		
	Protein (g)	1	13		
	Fat (g)	0	17		
	omega-3 (g)	0	0.18		
Banana muffin (1 muffin)	Kcal	152	301		
1 cup yogurt	Carb (g)	22	33	Wheat, eggs	*Traces of soy, nuts*
	Fibre (g)	3	3		
	Protein (g)	3	12		
	Fat (g)	6	14		
	omega-3 (g)	0.34	0.41		

Cinnamon Oatmeal with 1 Tablespoon ground flaxseed (1/2 cup ~125 ml)	Kcal	100	137		Traces of wheat, nuts, soy
	Carb (g)	17	19		
	Fibre (g)	3	5		
	Protein (g)	3	5		
	Fat (g)	2	5		
	omega-3 (g)	1.64	1.64		

#6 Recipes	For balance, pair at home with:	Canada's food guide	Key nutrition facts			Allergens	
				per portion (recipes)	per meal	*CONTAINS:*	*MAY CONTAIN:*
Quinoa Salad (take 2 portions of ¾ cup = 1 ½ cups)	**250 mL milk or kefir, orange slices**	Grain	Kcal	210	580	*none*	*Wheat, sulfites*
		F/V	Carb (g)	39	106		
		Milk/alt	Fibre (g)	5	12		
			Protein (g)	7	24		
			Fat (g)	2.5	8		
			omega-3 (g)	0.14	0.3		
Baked Salmon-potato cakes (take 2 patties)	**Fresh garden salad** **250 mL milk or yogurt**	Mt/alt	Kcal	120	517	*Milk, eggs, salmon*	*Sesame, mustard, soya and wheat*
		F/V	Carb (g)	15	56		
		Milk/alt	Fibre (g)	2	7		
			Protein (g)	7	33		
			Fat (g)	4	19		
			omega-3 (g)	0.6	1.22		
Tuna noodle casserole (take ¾ cup = 1 piece)	**Steamed vegetables and 250mL milk or yogurt**	Mt/alt	Kcal	240	463	*Milk, fish, wheat, soy*	*none*
		Grain	Carb (g)	23	59		
			Fibre (g)	3	8		
			Protein (g)	13	27		

			Fat (g)	11	13		
			omega-3 (g)	0.59	0.63		
Traditional mole with chickpeas and rice	**Fresh veggies**	Mt/alt	Kcal	280	502		
(take 1 cup mole + 2/3 cup rice)	**250 mL milk or yogurt**	Grain	Carb (g)	46	83	*none*	*Sesame mustard, soya, wheat, milk ingredients*
		Milk/alt	Fibre (g)	10	15		
		F/V	Protein (g)	11	25		
			Fat (g)	6	9		
			omega-3 (g)	0.08	0.13		
Curried zucchini soup with lentils		Mt/alt	Kcal	160	340		
(take 1 cup)	**15 low sodium rice crackers**	Grain	Carb (g)	28	65	*none*	*none*
		F/V	Fibre (g)	5	7		
			Protein (g)	8	11		
			Fat (g)	3	5		
			omega-3 (g)	0.29	0.3		

Appendix C : Breakdown of nutrients contents and average calories

Breakdown of nutrient contents						
AVERAGE	Kcal	Carb (g)	Fibre (g)	Protein (g)	Fat (g)	omega-3 (g)
breakfast meals	249	38	4	8	8	0.78
lunch meals	491	66	9	23	15	0.27
TOTAL	**740**	**104**	**13**	**31**	**23**	**1.05**

AVERAGE BREAKFAST	Kcal	Carb (g)	Fibre (g)	Protein (g)	Fat (g)	omega-3 (g)
Week 1	249	38	4	8	8	0.78
Week 2	301	36	2	12	13	0.32
Week 3	261	38	4	9	9	0.74

Week 4	297	32	2	12	14	0.38
Week 5	261	38	4	9	9	0.74
Week 6	256	33	3	10	10	0.61
TOTAL	270.8333333	35.83333333	3.166666667	10	10.5	0.718333333

AVERAGE LUNCH	Kcal	Carb (g)	Fibre (g)	Protein (g)	Fat (g)	omega-3 (g)
Week 1	491	66	9	23	15	0.27
Week 2	491	61.2	9.8	25	15.9	0.72
Week 3	371	56.59	11.3	14.9	6.7	0.68
Week 4	439.4	45.4	5.6	22	20.6	0.78
Week 5	404.4	51.55	7.9	21.3	14.16	0.86
Week 6	480.4	73.8	9.8	24	10.8	0.516
TOTAL	446.2	59.09	8.9	21.7	13.86	0.637666667

AVERAGE	Kcal	Carb (g)	Fibre (g)	Protein (g)	Fat (g)	omega-3 (g)
Week 1	740	104	13	31	23	1.05
Week 2	792	97	12	37	29	1
Week 3	632	95	15	24	16	1
Week 4	736	78	8	34	35	1
Week 5	665	90	12	30	23	2
Week 6	737	106	13	34	21	1.1
TOTAL	717	95	12.16666667	31.66666667	24.5	1.191666667