



The 2nd Nutrition and Cancer Networking Meeting 2022 was an in-person event held at the University of Newcastle on 11 May 2022

Conference on ‘Nutrition and breast cancer – translating evidence into practice’ Symposium three: Nutrition living with and beyond breast cancer

Tackling the adverse health effects of excess body fat in breast cancer: where does physical activity fit in?

JM Saxton^{1*} and C Wilson²

¹*School of Sport, Exercise & Rehabilitation Sciences, Faculty of Health Sciences, University of Hull, Cottingham Road, Hull HU6 7RX, UK*

²*Department of Oncology and Metabolism, The Medical School, University of Sheffield, Beech Hill Road, Sheffield S10 2RX, UK*

Weight gain is commonly observed during and after breast cancer treatment due to chemotherapy and endocrine therapies, induced menopause, changes in metabolism and food intake and decreased physical activity. Systematic reviews show that women who are overweight or obese at diagnosis, and those who gain weight, have poorer breast cancer survival outcomes than women of a healthy weight, irrespective of menopausal status. Excess body weight after breast cancer also increases the risk of type 2 diabetes mellitus and CVD. The adverse impact of excess body weight on survival outcomes is clearly shown for women with oestrogen receptor-positive (ER+) breast cancer, which accounts for 70% of all breast cancer cases. Higher body fat is thought to increase the risk of ER+ recurrence because of increased aromatase activity. However, this could be compounded by other risk factors, including abnormal insulin and adipokine metabolism, impaired anti-tumour immunity and chronic low-grade systemic inflammation. Observational evidence linking poorer survival outcomes with excess body fat and low physical activity in women recovering from early-stage curative-intent breast cancer treatment is reviewed, before reflecting on the proposed biological mechanisms. The issues and sensitivities surrounding exercise participation amongst overweight breast cancer patients is also discussed, before providing an overview of the co-design process involved in development of an intervention (support programme) with appropriate content, structure and delivery model to address the weight management challenges faced by overweight ER+ breast cancer patients.

Breast cancer: Weight gain: Diet: Exercise: Co-design

Excess body fat and impact on health outcomes in breast cancer

Published studies show that approximately two-thirds of women have excess body weight (overweight or obesity) at breast cancer diagnosis^(1–3). Furthermore, significant weight gain is frequently observed during

and after breast cancer management and this has been linked to chemotherapy treatment, being (or becoming) postmenopausal after diagnosis, changes in metabolism and food intake and decreased activity levels^(4–7). Systematic review evidence shows that women who are overweight/obese at breast cancer diagnosis, and those who gain weight, have poorer breast cancer and overall

Abbreviations: ER+, oestrogen receptor-positive; PA, physical activity.

***Corresponding author:** John Saxton, email john.saxton@hull.ac.uk

survival outcomes than healthy weight women, irrespective of menopausal status^(8–10). Excess body weight also increases the risk of type 2 diabetes mellitus, CVD^(11,12) and CVD mortality in breast cancer survivors⁽¹³⁾ and is linked to the primary occurrence of 12 other cancers⁽¹⁴⁾.

The adverse impact of excess body weight on post-diagnosis survival outcomes is clearly shown for women with oestrogen receptor-positive (ER+) disease^(15,16), which accounts for 70% of all incident cases⁽¹⁷⁾. Higher body fat increases the risk of ER+ recurrence because of increased aromatase activity and circulating levels of oestrogens and androgens⁽¹⁸⁾. This is compounded by other risk factors, including abnormal insulin and adipokine metabolism, impaired anti-tumour immunity and chronic low-grade systemic inflammation^(6,15). However, the adverse health impact of excess body weight after primary treatment extends beyond poorer survival outcomes, as overweight/obese ER+ breast cancer patients who gain weight after diagnosis ($\geq 5\%$ increase) are also reported to have poorer health-related quality of life and higher levels of cancer-related fatigue in comparison with women who maintain a stable body weight⁽¹⁹⁾. Although associations between intentional weight loss and survival outcomes in overweight/obese women recovering from primary breast cancer treatment are (as yet) less well established⁽²⁰⁾, considered together, this evidence provides a strong rationale for the development and evaluation of interventions that can provide the support women need to manage body weight after primary treatment for early-stage ER+ breast cancer⁽²¹⁾.

Physical activity after breast cancer treatment

Published meta-analyses show that a physically active lifestyle after early-stage breast cancer treatment is associated with improved survival outcomes and reduced risk of developing type 2 diabetes mellitus^(12,22–24). Furthermore, evidence suggests that these survival benefits can be gained from achievable levels of physical activity (PA) or structured exercise (i.e. consistent with current public health recommendations of ≥ 150 min/week of moderate-intensity aerobic activity)^(23,25), and with indications of a stronger mortality reduction for overweight and obese women⁽²²⁾. The first large-scale cohort study to investigate this reported a 50% improvement in breast cancer-specific mortality in women with ER+ tumours achieving the equivalent of a brisk 30 min walk on 6 d of the week *v.* their most inactive counterparts, a finding that was consistent for overweight/obese women⁽²⁶⁾. A physically active lifestyle after primary ER+ breast cancer treatment is also associated with improved quality of life and physical functioning^(19,27), and studies suggest that regular PA is an effective strategy for reducing fatigue and ameliorating the debilitating effects of other treatment side-effects, including pain, shortness of breath,

depression, insomnia and lymphoedema after breast cancer treatment^(28–33).

PA also has an important role in weight loss and long-term weight loss maintenance^(34,35). Several intervention studies show that PA/structured exercise in combination with tailored dietary advice results in clinically important weight loss (range 5–14%) in overweight breast cancer patients/survivors and postmenopausal women^(36–46) and induces greater weight loss than exercise or diet alone^(45,46). The same studies have shown that weight loss of $>5\%$ is accompanied by tangible improvements in biological risk markers of breast cancer recurrence and cardiometabolic disease (i.e. fasting insulin and circulating levels of inflammatory markers, leptin, oestrogens, testosterone and Sex hormone binding globulin (SHBG))^(37,39,41,45,47–49). Furthermore, regular purposeful PA can help to maintain or increase skeletal muscle mass during dietary-induced fat loss^(45,50,51) which increases total daily energy expenditure because of the direct association between skeletal muscle mass and BMR^(52,53), thereby enhancing the fat-reducing effects of hypoenergetic diets in ER+ breast cancer patients⁽⁵⁴⁾. Women treated for ER+ tumours receiving Tamoxifen seem to be particularly susceptible to adverse body composition changes (i.e. increases in overall body fat and truncal fat), independent of changes in body weight⁽⁵⁵⁾. Thus, an improved knowledge of body composition changes accompanying weight loss interventions (i.e. changes in body fat compartmentalisation and lean body mass) is important for gaining further insight into the mechanisms underpinning changes in biological risk markers of cancer recurrence and cardiometabolic disease in this population.

Intervention studies

Intervention studies have reported a range of health benefits following interventions to increase PA and improve dietary behaviours after primary treatment for early-stage breast cancer, including sustained PA behaviour change and improvements in body composition, quality of life and risk markers associated with cancer recurrence and cardiometabolic disease^(37,38,41–43,56). While these studies have demonstrated the feasibility and efficacy of lifestyle interventions for breast cancer survivors, an important challenge is to design practically implementable methods of developing the skills and confidence women need for longer-term health behaviour change, while also overcoming the challenges of embedding such provision within the National Health Service. Offering a route to supported lifestyle behaviour change would address an important unmet need for women and their treating clinicians at this opportune ‘teachable moment’.

Support for health behaviour change as part of the National Health Service care pathway

Support for health behaviour change after primary treatment for breast cancer is limited to that provided by



prominent UK cancer charities. For example, Breast Cancer Now offers an on-line course and book/printed materials ('Moving Forward') to help women adjust to life after breast cancer treatment. This takes place over half a day for 3 or 4 weeks and aims to provide information, support and professional guidance on how to cope with and adjust to life after breast cancer treatment⁽⁵⁷⁾. Macmillan Cancer Support offers the Recovery Package after completion of primary treatment comprising a Holistic Needs Assessment, treatment and cancer care reviews with a healthcare professional and an education/support event such as a Health and Wellbeing Clinic⁽⁵⁸⁾. There remains a gap however, in longer-term provision of tailored (bespoke) lifestyle support, specifically designed to address the barriers to effective weight loss that many women experience after primary treatment for breast cancer. This means that offering a route to accessible and adoptable weight management support would address an important unmet need for women and their treating clinicians at what is frequently an opportune 'teachable moment' for patients⁽⁵⁹⁾.

Understanding the barriers to weight management

It is important to understand factors which can act as barriers to healthy lifestyle behaviours and sustainable weight loss after breast cancer treatment. Qualitative studies have identified a range of emotional needs, concerns and anxieties related to breast cancer and its treatments that interventions for supporting health behaviour change must address, including cancer-related physical symptoms (e.g. upper extremity motion restriction, lymphoedema, fatigue, etc.), low confidence and self-esteem, family and work schedules, body image concerns and fear of recurrence^(60–66). In addition, women commonly experience deficits in lifestyle education, citing a lack of accurate information and support from health professionals, particularly regarding the management of treatment-induced physical limitations⁽⁶⁰⁾. Providing a supportive environment to help women address these barriers seems also to be important for helping to build the skills and confidence needed for sustainable lifestyle behaviour change.

Group-based lifestyle interventions

Studies show that group-based interventions, incorporating evidence-based behaviour change strategies and providing an opportunity for peer-support and a forum for addressing the anxieties and challenges women face after primary breast cancer treatment, can serve as a strong platform for building the skills and confidence needed to increase engagement in regular PA and healthy dietary behaviours. Successful group-based weight-loss interventions have used a variety of delivery formats, including face-to-face (closed-group) workshops for 8–15 women and individual or group-based telephone support, alongside remote-support methods such as

emails, text-messaging and printed mail-outs^(37,38,41–43,56). The use of self-regulatory behaviour change techniques (e.g. goal setting, self-monitoring), inclusion of an educational component, setting of graded tasks and establishing a structure for frequent contact and social support is consistent with best-evidence strategies for promoting changes in dietary and PA behaviours in the general population⁽⁶⁷⁾ and in people living with and beyond cancer⁽⁶⁸⁾.

Co-design of an accessible and adoptable weight management intervention

Drawing on this empirical evidence and guided by the MRC Framework for Developing and Evaluating Complex Interventions⁽⁶⁹⁾ and the Person-Based Approach to Intervention Development⁽⁷⁰⁾, we set out to co-design an accessible and adoptable weight loss intervention (support programme) that prioritises the issues and concerns faced by overweight women recovering from ER+ breast cancer treatment. The initial phase of this research involved qualitative focus groups with breast cancer patients and healthcare professionals. The results of this qualitative phase were then used to develop two-stage co-design workshops to understand the support structures required to produce and maintain positive health behaviour change in this population, e.g. which elements would be essential to a weight loss programme and which elements would need to have a flexible component.

Intervention delivery model

The intervention comprises a 12-month programme of group-based *Support & Skills Workshops*, involving educational and practical PA components, delivered by trained instructors and registered dietitians. The design of the group-based intervention enables it to be delivered via video conferencing technologies (e.g. Zoom, Teams, etc.). Having the option to deliver the intervention remotely offers safety advantages in the post-Covid-19 era and removes the need to travel to a facility. Furthermore, having the flexibility of virtual delivery brings other advantages such as improved scalability and cost-efficiency. Workshops are complemented by telephone/email support and participants have access to support from their peers and an instructor via a bespoke web-platform. High-quality intervention materials help women to achieve meaningful PA and dietary behaviour change. The intervention is designed to be more intensive during the first 6 months, followed by a 6-month period of maintenance support.

Feasibility testing

A randomised controlled feasibility study recruited 21 breast cancer patients from two hospital Trusts in the North of England and the intervention was piloted

over 6 months. Women were randomised into two groups (intervention or standard care control) and because of Covid-19 restrictions, the intervention was delivered remotely using video-conferencing. The group-based *Support & Skills Workshops* involved peer-to-peer virtual interactions between small groups of patients and the instructor. In addition, real-time instructor-led exercise classes were delivered virtually as part of the sessions. The pilot study has yielded positive preliminary results, in terms of weight loss and patient-reported outcomes, and we aim to progress this developmental work into a definitive multi-centre trial.

Summary

In the UK there are over 55 000 new breast cancer cases per year and approximately two-thirds of women are obese or overweight at diagnosis. Obesity, weight gain and low levels of PA after diagnosis are associated with worse survival in women being treated for early-stage disease. The importance of healthy lifestyle behaviours for helping to prevent the adverse effects of weight gain after a breast cancer diagnosis is now widely acknowledged. Exercise in combination with dietary advice has been shown to evoke favourable body composition changes in breast cancer patients^(37,38,41–43,56). However, there remains a gap in longer-term provision of tailored (bespoke) lifestyle support which is specifically designed to address the barriers to effective weight loss that many women experience after primary treatment for breast cancer. We used a co-design approach to enable the development of an intervention (support programme) with appropriate content, structure and delivery model to address the weight management challenges faced by overweight ER+ breast cancer patients. Offering a route to supported lifestyle behaviour change addresses an important unmet need for women and their treating clinicians at an opportune ‘teachable moment’.

Acknowledgements

Not applicable.

Financial Support

Yorkshire Cancer Research.

Conflict of Interest

None.

Authorship

The authors had sole responsibility for all aspects of preparation of this paper.

References

1. Crozier JA, Moreno-Aspitia A, Ballman KV *et al.* (2013) Effect of body mass index on tumor characteristics and disease-free survival in patients from the HER2-positive adjuvant trastuzumab trial N9831. *Cancer* **119**, 2447–2454.
2. Bernstein L, Deapen D, Cerhan JR *et al.* (1999) Tamoxifen therapy for breast cancer and endometrial cancer risk. *J Natl Cancer Inst* **91**, 1654–1662.
3. Cecchini RS, Swain SM, Costantino JP *et al.* (2016) Body mass index at diagnosis and breast cancer survival prognosis in clinical trial populations from NRG oncology/NSABP B-30, B-31, B-34, and B-38. *Cancer Epidemiol Biomarkers Prev* **25**, 51–59.
4. Vance V, Mourtzakis M, McCargar L *et al.* (2011) Weight gain in breast cancer survivors: prevalence, pattern and health consequences. *Obes Rev* **12**, 282–294.
5. Trestini I, Carbognin L, Monteverdi S *et al.* (2018) Clinical implication of changes in body composition and weight in patients with early-stage and metastatic breast cancer. *Crit Rev Oncol Hematol* **129**, 54–66.
6. McTiernan A (2018) Weight, physical activity and breast cancer survival. *Proc Nutr Soc* **77**, 403–411.
7. Irwin ML, McTiernan A, Baumgartner RN *et al.* (2005) Changes in body fat and weight after a breast cancer diagnosis: influence of demographic, prognostic, and lifestyle factors. *J Clin Oncol* **23**, 774–782.
8. Protani M, Coory M & Martin JH (2010) Effect of obesity on survival of women with breast cancer: systematic review and meta-analysis. *Breast Cancer Res Treat* **123**, 627–635.
9. Chan DS, Vieira AR, Aune D *et al.* (2014) Body mass index and survival in women with breast cancer-systematic literature review and meta-analysis of 82 follow-up studies. *Ann Oncol* **25**, 1901–1914.
10. Playdon MC, Bracken MB, Sanft TB *et al.* (2015) Weight gain after breast cancer diagnosis and all-cause mortality: systematic review and meta-analysis. *J Natl Cancer Inst* **107**, djv275.
11. Knopf MT & Coviello J (2011) Lifestyle interventions for cardiovascular risk reduction in women with breast cancer. *Curr Cardiol Rev* **7**, 250–257.
12. Lohmann AE, Ennis M, Taylor SK *et al.* (2017) Metabolic factors, anthropometric measures, diet, and physical activity in long-term breast cancer survivors: change from diagnosis and comparison to non-breast cancer controls. *Breast Cancer Res Treat* **164**(2), 451–460.
13. Bradshaw PT, Stevens J, Khankari N *et al.* (2016) Cardiovascular disease mortality among breast cancer survivors. *Epidemiology* **27**, 6–13.
14. WCRF/AICR (2018) *Continuous Update Project Expert Report. Diet, nutrition, physical activity and breast cancer survivors.*
15. Picon-Ruiz M, Morata-Tarifa C, Valle-Goffin JJ *et al.* (2017) Obesity and adverse breast cancer risk and outcome: mechanistic insights and strategies for intervention. *CA Cancer J Clin* **67**, 378–397.
16. Jiralerspong S & Goodwin PJ (2016) Obesity and breast cancer prognosis: evidence, challenges, and opportunities. *J Clin Oncol* **34**, 4203–4216.
17. Lumachi F, Brunello A, Maruzzo M *et al.* (2013) Treatment of estrogen receptor-positive breast cancer. *Curr Med Chem* **20**, 596–604.
18. Bhardwaj P, Au CC, Benito-Martin A *et al.* (2019) Estrogens and breast cancer: mechanisms involved in obesity-related development, growth and progression. *J Steroid Biochem Mol Biol* **189**, 161–170.

19. Voskuil DW, van Nes JG, Junggeburst JM *et al.* (2010) Maintenance of physical activity and body weight in relation to subsequent quality of life in postmenopausal breast cancer patients. *Ann Oncol* **21**, 2094–2101.
20. Jackson SE, Heinrich M, Beeken RJ *et al.* (2017) Weight loss and mortality in overweight and obese cancer survivors: a systematic review. *PLoS ONE* **12**, e0169173.
21. Anderson AS, Martin RM, Renehan AG *et al.* (2021) Cancer survivorship, excess body fatness and weight-loss intervention—where are we in 2020? *Br J Cancer* **124**, 1057–1065.
22. Zhong S, Jiang T, Ma T *et al.* (2014) Association between physical activity and mortality in breast cancer: a meta-analysis of cohort studies. *Eur J Epidemiol* **29**, 391–404.
23. Lahart IM, Metsios GS, Nevill AM *et al.* (2015) Physical activity, risk of death and recurrence in breast cancer survivors: a systematic review and meta-analysis of epidemiological studies. *Acta Oncol* **54**, 635–654.
24. Friedenreich CM, Stone CR, Cheung WY *et al.* (2019) Physical activity and mortality in cancer survivors: a systematic review and meta-analysis. *JNCI Cancer Spectr* **4**, pkz080.
25. CMOs (2011) Start Active, Stay Active: a report on physical activity from the four home countries' Chief Medical Officers. Available at http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_128209 London: Department of Health.
26. Holmes MD, Chen WY, Feskanich D *et al.* (2005) Physical activity and survival after breast cancer diagnosis. *JAMA* **293**, 2479–2486.
27. Zhang X, Li Y, Liu D (2019) Effects of exercise on the quality of life in breast cancer patients: a systematic review of randomized controlled trials. *Support Care Cancer* **27**(1), 9–21.
28. Mustian KM, Alfano CM, Heckler C *et al.* (2017) Comparison of pharmaceutical, psychological, and exercise treatments for cancer-related fatigue: a meta-analysis. *JAMA Oncol* **3**, 961–968.
29. Mustian KM, Griggs JJ, Morrow GR *et al.* (2006) Exercise and side effects among 749 patients during and after treatment for cancer: a University of Rochester Cancer Center Community Clinical Oncology Program Study. *Support Care Cancer* **14**, 732–741.
30. Juvet LK, Thune I, Elvsaas IKO *et al.* (2017) The effect of exercise on fatigue and physical functioning in breast cancer patients during and after treatment and at 6 months follow-up: a meta-analysis. *Breast* **33**, 166–177.
31. Nakano J, Hashizume K, Fukushima T *et al.* (2018) Effects of aerobic and resistance exercises on physical symptoms in cancer patients: a meta-analysis. *Integr Cancer Ther* **17**, 1048–1058.
32. Baumann FT, Reike A, Reimer V *et al.* (2018) Effects of physical exercise on breast cancer-related secondary lymphedema: a systematic review. *Breast Cancer Res Treat* **170**, 1–13.
33. Irwin ML, Cartmel B, Gross CP *et al.* (2015) Randomized exercise trial of aromatase inhibitor-induced arthralgia in breast cancer survivors. *J Clin Oncol* **33**, 1104–1111.
34. Clamp LD, Hume DJ, Lambert EV *et al.* (2018) Successful and unsuccessful weight-loss maintainers: strategies to counteract metabolic compensation following weight loss. *J Nutr Sci* **7**, e20.
35. Ostendorf DM, Caldwell AE, Creasy SA *et al.* (2019) Physical activity energy expenditure and total daily energy expenditure in successful weight loss maintainers. *Obesity (Silver Spring)* **27**, 496–504.
36. Goodwin PJ, Segal RJ, Vallis M *et al.* (2014) Randomized trial of a telephone-based weight loss intervention in postmenopausal women with breast cancer receiving letrozole: the LISA trial. *J Clin Oncol* **32**, 2231–2239.
37. Pakiz B, Flatt SW, Bardwell WA *et al.* (2011) Effects of a weight loss intervention on body mass, fitness, and inflammatory biomarkers in overweight or obese breast cancer survivors. *Int J Behav Med* **18**, 333–341.
38. Rock CL, Flatt SW, Byers TE *et al.* (2015) Results of the exercise and nutrition to enhance recovery and good health for you (ENERGY) trial: a behavioral weight loss intervention in overweight or obese breast cancer survivors. *J Clin Oncol* **33**, 3169–3176.
39. Harrigan M, Cartmel B, Loftfield E *et al.* (2016) Randomized trial comparing telephone versus In-person weight loss counseling on body composition and circulating biomarkers in women treated for breast cancer: the lifestyle, exercise, and nutrition (LEAN) study. *J Clin Oncol* **34**, 669–676.
40. Reeves M, Winkler E, McCarthy N *et al.* (2017) The living well after breast cancer pilot trial: a weight loss intervention for women following treatment for breast cancer. *Asia Pac J Clin Oncol* **13**, 125–136.
41. Befort CA, Klemp JR, Austin HL *et al.* (2012) Outcomes of a weight loss intervention among rural breast cancer survivors. *Breast Cancer Res Treat* **132**, 631–639.
42. Christifano DN, Fazzino TL, Sullivan DK *et al.* (2016) Diet quality of breast cancer survivors after a six-month weight management intervention: improvements and association with weight loss. *Nutr Cancer* **68**, 1301–1308.
43. Travier N, Fonseca-Nunes A, Javierre C *et al.* (2014) Effect of a diet and physical activity intervention on body weight and nutritional patterns in overweight and obese breast cancer survivors. *Med Oncol* **31**, 783.
44. Imayama I, Ulrich CM, Alfano CM *et al.* (2012) Effects of a caloric restriction weight loss diet and exercise on inflammatory biomarkers in overweight/obese postmenopausal women: a randomized controlled trial. *Cancer Res* **72**, 2314–2326.
45. van Gemert WA, Schuit AJ, van der Palen J *et al.* (2015) Effect of weight loss, with or without exercise, on body composition and sex hormones in postmenopausal women: the SHAPE-2 trial. *Breast Cancer Res* **17**, 120.
46. Foster-Schubert KE, Alfano CM, Duggan CR *et al.* (2012) Effect of diet and exercise, alone or combined, on weight and body composition in overweight-to-obese postmenopausal women. *Obesity (Silver Spring)* **20**, 1628–1638.
47. Campbell KL, Foster-Schubert KE, Alfano CM *et al.* (2012) Reduced-calorie dietary weight loss, exercise, and sex hormones in postmenopausal women: randomized controlled trial. *J Clin Oncol* **30**, 2314–2326.
48. Mason C, Foster-Schubert KE, Imayama I *et al.* (2011) Dietary weight loss and exercise effects on insulin resistance in postmenopausal women. *Am J Prev Med* **41**, 366–375.
49. Imayama I, Alfano CM, Neuhouser ML *et al.* (2013) Weight, inflammation, cancer-related symptoms and health related quality of life among breast cancer survivors. *Breast Cancer Res Treat* **140**, 159–176.
50. Schmitz KH, Ahmed RL, Hannan PJ *et al.* (2005) Safety and efficacy of weight training in recent breast cancer survivors to alter body composition, insulin, and insulin-like growth factor axis proteins. *Cancer Epidemiol Biomark Prev* **14**, 1672–1680.
51. Irwin ML, Alvarez-Reeves M, Cadmus L *et al.* (2009) Exercise improves body fat, lean mass, and bone mass in breast cancer survivors. *Obesity (Silver Spring)* **17**, 1534–1541.



52. Cunningham JJ (1991) Body composition as a determinant of energy expenditure: a synthetic review and a proposed general prediction equation. *Am J Clin Nutr* **54**, 963–969.
53. Stiegler P & Cunliffe A (2006) The role of diet and exercise for the maintenance of fat-free mass and resting metabolic rate during weight loss. *Sports Med* **36**, 239–262.
54. Artene DV, Bordea CI & Blidaru A (2017) Results of 1-year diet and exercise interventions for ER +/PR ±/HER2- breast cancer patients correlated with treatment type. *Chirurgia (Bucur)* **112**, 457–468.
55. Sheean PM, Hoskins K & Stolley M (2012) Body composition changes in females treated for breast cancer: a review of the evidence. *Breast Cancer Res Treat* **135**, 663–680.
56. Campbell KL, Van Patten CL, Neil SE *et al.* (2012) Feasibility of a lifestyle intervention on body weight and serum biomarkers in breast cancer survivors with overweight and obesity. *J Acad Nutr Diet* **112**, 559–567.
57. Now BC breast cancer now moving forward online course. <https://breastcancer.org/information-support/support-you/moving-forward-online-course>.
58. Macmillan Cancer Support Macmillan Cancer Support: the recovery package. https://www.macmillan.org.uk/documents/aboutus/health_professionals/macvoice/sharinggood_practice_therecoverypackage.pdf.
59. Demark-Wahnefried W, Aziz NM, Rowland JH *et al.* (2005) Riding the crest of the teachable moment: promoting long-term health after the diagnosis of cancer. *J Clin Oncol* **23**, 5814–5830.
60. Binkley JM, Harris SR, Levangie PK *et al.* (2012) Patient perspectives on breast cancer treatment side effects and the prospective surveillance model for physical rehabilitation for women with breast cancer. *Cancer* **118**, 2207–2216.
61. Brunet J, Taran S, Burke S *et al.* (2013) A qualitative exploration of barriers and motivators to physical activity participation in women treated for breast cancer. *Disabil Rehabil* **35**, 2038–2045.
62. Aycinena AC, Valdovinos C, Crew KD *et al.* (2017) Barriers to recruitment and adherence in a randomized controlled diet and exercise weight loss intervention among minority breast cancer survivors. *J Immigr Minor Health* **19**, 120–129.
63. Campbell-Enns H & Woodgate R (2015) The psychosocial experiences of women with breast cancer across the lifespan: a systematic review protocol. *JBIR Database System Rev Implement Rep* **13**, 112–121.
64. Pedersen B, Groenkjaer M, Falkmer U *et al.* (2017) Understanding the essential meaning of measured changes in weight and body composition among women during and after adjuvant treatment for breast cancer: a mixed-methods study. *Cancer Nurs* **40**, 433–444.
65. Hefferon K, Murphy H, McLeod J *et al.* (2013) Understanding barriers to exercise implementation 5-year post-breast cancer diagnosis: a large-scale qualitative study. *Health Educ Res* **28**, 843–856.
66. Breast Cancer Care Survey 2. <https://www.breastcancercare.org.uk/about-us/media/press-releases/breast-cancer-patients-unprepared-damaging-impact-confidence-sexual> (accessed 29 August 2019).
67. Greaves CJ, Sheppard KE, Abraham C *et al.* (2011) Systematic review of reviews of intervention components associated with increased effectiveness in dietary and physical activity interventions. *BMCPublic Health* **11**, 119.
68. Turner RR, Steed L, Quirk H *et al.* (2018) Interventions for promoting habitual exercise in people living with and beyond cancer. *Cochrane Database Syst Rev* **9**, CD010192.
69. Craig P, Dieppe P, Macintyre S *et al.* (2008) Developing and evaluating complex interventions: the new Medical Research Council guidance. *Br Med J* **337**, a1655.
70. Yardley L, Ainsworth B, Arden-Close E *et al.* (2015) The person-based approach to enhancing the acceptability and feasibility of interventions. *Pilot Feasibility Stud* **1**, 37.