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Individualised physical activity and physiotherapy behaviour change intervention tool for breast cancer survivors using self-efficacy and COM-B: feasibility study.

Short running title- Physical activity breast cancer feasibility study

Abstract

Objective

Breast cancer survivors who are physically active have lower recurrence and all-cause mortality. Breast cancer survivors often struggle to initiate and maintain physically active lifestyles. Barriers include psychosocial, environmental, and musculoskeletal factors. An individualised physical activity intervention, informed by physiotherapy and behaviour change principles, may comprehensively address these barriers. This study tests the feasibility of this intervention.

Methods

Following ethical approval and informed consent, stage I and II breast cancer survivors within 18 months of diagnosis were recruited from a secondary care NHS breast cancer unit. The intervention used tools combining musculoskeletal dysfunction, self-efficacy measurement and the COM-B model to allow personal tailoring of intervention techniques. The feasibility of recruitment, retention, acceptability and practicality of delivery of the physical activity intervention was tested using a single arm study.

Results

Nine of 36 (25%) potential participants were recruited. Seven (77%) were retained to the study end. All participants reported that the intervention was acceptable. Eight would recommend the intervention and reported that their physical activity level increased due to the intervention. The intervention was practical to deliver within routine physiotherapy appointments.

Conclusions

This small feasibility study has promising findings and will now need to be tested with more participants.

Keywords:

Individualised intervention

Breast Cancer

Physical Activity

Introduction

Breast cancer survivors who are more physically active have better physical and psychological health (Irwin et al., 2008, Lahart et al., 2015). Lahart et al's (2015) systematic review and meta-analysis estimated a 48% lower risk of all-cause mortality and 41% lower risk of breast cancer specific mortality in those with high levels of physical activity (PA), compared to those reporting no or low PA levels post breast cancer diagnosis. Estimates suggest that only 30-40% of breast cancer survivors reach adequate levels of PA (Irwin et al., 2008, Tan et al 2009), defined by the UK Chief Medical Officer (2019) as 150 minutes of moderate PA per week or 75 minutes of vigorous activity weekly. This has led to multiple studies aiming to increase PA activity levels in breast cancer survivors. Studies have included interventions that used specific PA activity prescriptions such as dragon boat racing, Nordic walking, (Courneya et al., 2001, Fields et al., 2016) and multiple fixed term exercise classes (Short et al., 2013, Mutrie et al., 2007). These interventions have limited acceptability to the participants during the intervention or accessibility following the intervention, and have failed due to psychosocial or musculoskeletal (MSK) factors (Bourke et al., 2013, Heffron et al., 2013, Mutrie., et al 2007., Short et al., 2013). In contrast, interventions that are tailored to breast cancer survivors show more sustained impact on PA behaviour (Baumann et al., 2017, Bluethmann et al., 2015).

To achieve longer term change, it is argued that interventions should be designed to address self-efficacy (Stacey et al, 2015), and barriers and facilitators to maintaining physical activity behaviour (Bourke et al., 2013). Behavioural science suggest theories and frameworks can support behaviour change through facilitating an understanding of what drives the target behaviours, the barriers and facilitators to the target behaviour, and suggestions for how barriers can be overcome. For example, the Behaviour Change Wheel and COM-B Model (Capability Opportunity Motivation - Behaviour) can support identification of the predictors of behaviour, and consequently the appropriate intervention techniques to support the target behaviour (Michie et al. 2011). Barriers to maintaining beneficial levels of physical activity can

be primarily grouped into three sections, which broadly overlap with components of the COM-B model. These are:

1. Physical and musculoskeletal (MSK) (related to ‘Capability’). This is concerned with side-effects of breast cancer treatments that include shoulder, arm and leg pain, weakness and stiffness (Hidding et al., 2014; De Groef et al 2016, Beckwee et al., 2017).
2. Contextual and environmental (related to ‘Opportunity’). This is concerned with the lack of time, money and access to facilities, as well as social support (Hefferon et al., 2013; Olson et al 2014).
3. Psychological and psychosocial (related to ‘Motivation’). This is concerned with fear, self-consciousness and not having a habit to be physically active (Hefferon et al., 2013; Olson et al 2014).

Increasingly, musculoskeletal factors (‘Capability’ component above) have been identified as a barrier to initiating and sustaining physically active lifestyles for breast cancer survivors (Lee et al 2016; Beckwee et al., 2017). These barriers are associated with treatments for breast cancer and include problems such as shoulder and leg weakness, pain and restrictions in movement (Hidding et al., 2014; Groef et al 2016). Evidence is increasingly showing that these musculoskeletal problems can be responsive to specific tailored exercise prescriptions (McNeely et al., 2010, Brown et al., 2014).

Therefore, to support increased PA in breast cancer survivors, an intervention is needed that is tailored to address both psychological barriers and motivators to PA maintenance, as well as taking into account individual physical restrictions. An evidence-based intervention was developed using the COM-B model and Behaviour Change Wheel (Michie et al., 2011, 2014). The intervention enabled participants to develop their own physical activity goal(s), which address their specific barriers and enablers to PA, and provision of an individual exercise prescription for any musculoskeletal dysfunction(s).

The aims of this study were to assess whether it is feasible to deliver an individually tailored physiotherapy and behaviour change based PA intervention for breast

cancer survivors in an NHS setting, and to establish the acceptability of the intervention**, and the feasibility of testing this in a trial.**

Methods

Study design and participants

A single arm, intervention study (Nyrop et al., 2014) was used to test the feasibility of the individually tailored physiotherapy and behaviour change based physical activity intervention. Following informed consent, participants were recruited from an open access follow up clinic (OAFU), in a large regional, secondary care, urban Academic Health Science Centre breast cancer unit. To allow calculation of variance for future sample size calculation we aimed to recruit ten participants (Julious 2005). Inclusion criteria were: Stage 0- II breast cancer survivors within 18 months of initial diagnosis, who were physically inactive, as defined by the UK Chief Medical Officer (2019). The exclusion criteria were; inability to speak and read English, stage III- IV breast cancer, concurrent unstable cardiac hypertension or respiratory disease, defined as physically active by the Chief Medical Officer guidelines (2019) and cognitive dysfunction. Ethical approval was obtained from the North-West Preston Research Ethics Committee. (Reference: 16/NW/0895).

Feasibility outcome measures

The participants were recruited from OAFU. To assess study recruitment rate, data was collected on the numbers of patients within OAFU; the numbers of potentially eligible patients within OAFU; the numbers that attended OAFU; the numbers agreeing to allow the PI to approach them; of these, the numbers that were still eligible once approached and of these potential recruits, the numbers recruited. Where possible, information on why patients did not want to be recruited was recorded. To assess study retention rates - data was generated to measure the retention of the participants to the study by recording the numbers of participants' completing the study procedures at all timepoints. Acceptability of the intervention by recording which components of the study the participants accepted, and by a satisfaction questionnaire composed of 21 questions: seventeen questions had responses on a 5-point Likert scale (strongly disagree, disagree, undecided, agree, strongly agree) and four questions had free text responses. The questions were

designed to gather data on the acceptability by the participants of: face to face meetings, follow up phone calls, physical activity support and related material. The Likert scale questions assessed agreement with statements about the burden, ethicality and intervention coherence of the study design, timing, content, and methods; their affective attitude towards the study in general, and perceived effectiveness of the study at changing their behaviour, as proposed by Sekhon et al., (2017). The practicality of delivering the intervention was assessed from the time taken to deliver the individual intervention components. Intervention fidelity was assessed and measured by the participants 'receipt' of the intervention components, as defined by Rixon et al., 2016. The physiotherapist's intervention implementation diary recorded for every participant at each timepoint: what behaviour change techniques were used/not used; what physical activity goals were achieved and what changes and adaptations were made to these goals; and which exercises were done/not done and progressed. These measurements also formed an assessment of the active engagement of the participants in the intervention, so could be seen as a form of assessment of the receipt and enactment of the intervention (Rixon et al., 2016).

Secondary clinical outcome measures

Demographic information was collected using a questionnaire, completed at the point of recruitment. Measures used have all been validated in cohorts of people with breast cancer and, with the exception of the physical activity ability testing, were self-report using a Likert scale. Musculoskeletal dysfunction with Disability of Arm Shoulder and Hand (DASH) Score, a 30-item outcome measure, was used to measure shoulder and arm function (Harrington et al 2014). Western Ontario & McMaster Universities Osteoarthritis Index (WOMAC), a 24-item outcome measure was used to assess lower limb pain, stiffness and function (Swenson et al., 2013). Godin-Shephard Leisure-Time Exercise Questionnaire (GLTEQ), a 4-item outcome measure, was used to assess self- reported levels of PA on a weekly basis (Amireault et al 2015). The 6-Minute Walk Test (6MWT), a timed and distance measured walk test was used to objectively assess the participants functional exercise capacity and capability (Schmidt et al., 2013). The Barrier and Task Self Efficacy Scale, a 13-item scale, was used to assess psychological, social and

environmental barriers to PA (Rogers et al. 2005, 2006).

Procedure

This was an 8-week intervention with four study time points (see Table 1).

The initial (T1) meeting was face-to-face in a secondary care physiotherapy department. The meeting explored participants physical activity behaviour, strategies to address and target any barriers to physical activity; to develop appropriate physical activity goal(s), and an exercise prescription to address their musculoskeletal barriers to perform PA. This is described in detail in the intervention section.

Two telephone calls were conducted, one each during week 2 (T2) and week 6 (T3). These aimed to support behaviour change, by exploring barriers and enablers to achieving the previously set physical activity goals. This resulted in the physiotherapists and participant exploring ways to address the barriers, for example through changes to the goals themselves or consideration of different times or places to achieve the behaviour. The participants' exercise prescription was progressed in line with the number of repetitions that they were achieving. A follow-up visit and assessment at the physiotherapy department was undertaken at week 8 (T4). This included repeating the outcome measures and an invitation to complete an anonymous intervention satisfaction questionnaire.

Intervention

Tailored support for greater physical activity

The barrier and task self- efficacy score outcome measure, was used as the basis for the tailoring of behaviour change techniques and physical activity goals that addressed the individual participant's barriers and enablers to PA. Following completion of the outcome measures, participants were invited to read a brief overview of the benefits of PA to their health and well-being. While they were reading this, the physiotherapist examined their self-efficacy scores to tailor the intervention (see Table 2). The domains of the Barrier and Task Self Efficacy Scale are; time, discipline, priority, weather, tiredness, physical health, interest, enjoyment or companion (Rogers et al 2006), which were mapped onto the COM-B model and

Behaviour Change Wheel by the first author to create an intervention tailoring tool. The development process for the tool used the COM-B model and Behaviour Change Wheel, and followed the process described in Michie et al., (2014). This was an in-depth evidence-based analysis of the desired behaviour of PA in breast cancer survivors. The validated Barrier and Task Self Efficacy Scale (Rogers et al 2006) was used to assess the individual's behaviour and barriers to PA, and the mapping of these onto the COM-B model allowed identification of the appropriate behaviour change techniques so the intervention could easily be personally tailored to address each individual's barriers to PA (Table 2). The tailored intervention took the form of a discussion that covered the participants' knowledge of the benefits of PA; personal experiences of PA; self-efficacy around performing PA; and barriers and facilitators to PA including contextual and environmental, psychological and psychosocial, and physical and musculoskeletal barriers. For example, if the participants indicated that the discipline to exercise was one of their barriers to engagement with a physical activity goal, the prompts and clues that could enable the performance of physical activity goals were discussed e.g. power walking to or from work or another daily activity. In this way it was possible to tailor the participants PA goal to address their specific barriers and facilitators.

Tailored exercise prescription

The intervention was delivered by an experienced physiotherapist. The Disability of Arm Shoulder and Hand (DASH) and Western Ontario & McMaster Universities Osteoarthritis Index (WOMAC) scores were used to develop each participant exercise prescription. An evidence-based progressive program of exercises was developed from exercises shown to improve musculoskeletal barriers to PA such as weakness and stiffness as detailed in Tables 3 and 4. The DASH score was used to measure upper quadrant musculoskeletal dysfunction (Harrington et al 2014). The WOMAC score was used to measure lower limb musculoskeletal dysfunction (Swenson et al., 2013). By comparing these scores with standardised scores for breast cancer survivors, the lead author developed a decision tree to guide the selection and progression of the exercise prescription. Behaviour change techniques such as training and demonstration were used to teach the participants the exercise

prescription. Participants were also given a set of graded exercise sheets, to guide them in how to progress the exercises themselves.

Statistical analysis

The feasibility study measures were descriptive, and presented using means and standard deviations. The overall recruitment rate was calculated by the ratio between the numbers approached and the numbers recruited; the monthly recruitment rate by the ratio between the total number recruited and the months of recruitment (Walters et al., 2017). The retention rates, objective acceptability rates and fidelity were calculated by percentages of the total numbers retained. This enabled the assessment of feasibility of implementation of the intervention by comparison with other similar studies within the NHS such as (Daley et al., 2007, Fields et al., 2016, Mutrie et al., 2007), in addition to other similar interventions with the host NHS health science institute. The percentage of participants reporting each of the different Likert response options within the satisfaction questionnaire was reported.

For the secondary clinical outcomes, data was analysed using SPSS version 23. Normality of the data was tested using the Shapiro-Wilk test and either mean ± standard deviation (SD) or median and interquartile range (IQR) and percentages calculated. T-tests or Wilcoxon Rank Sum Tests assessed changes in secondary clinical outcome measures between T1 and T4

Results

Recruitment

Nine out of 25 eligible participants were recruited from open access follow up clinic over five months, giving a recruitment rate of 36%, and 1.8 monthly recruitment rate. See figure 1 for further details and Table 5 for participant demographics.

Retention

Seven of the nine participants (77%) completed the study. One participant was lost to follow up after the second telephone call and one participant was unable to attend

the final interview, but completed all outcome measures that could be done remotely (not the timed walk).

Intervention acceptability

All participants accepted all aspects of the intervention at T1. They accepted the subsequent telephone calls and outcome measures and most reported that they had increased their physical activity. At T2, only two participants (29%) self-reported not having done MSK exercises, and only one (14%) at T3. Eight out of nine found the outcome measures acceptable to complete; seven, found the 6-minute walk test acceptable, one participant had sciatica and struggled to walk whereas the other struggled with the time required.

Analysis of the participant's comments from the acceptability questionnaire suggests the intervention was found acceptable (Table 6). Eighty percent of the participants would strongly recommend the intervention and eighty-seven percent reported that it changed their attitude to physical activity, as one participant said; 'I now realise how important exercise is and that I must make time for it and do more than prior to my diagnosis.' Eighty-seven percent felt that the burden of the intervention was outweighed by the benefits. All participants felt able to incorporate physical activity into their lifestyle, with several commenting that they had not anticipated how much better they would feel.

Practicality

The T1 mean intervention time of 61 minutes (SD = 22) is within line with similar complex physiotherapy, psychology and nursing interventions within the host institution. The first telephone call took 13 minutes on average (SD = 4) and the second 12 minutes (SD = 4). The mean numbers of calls made in order to talk to each participant at T2 was 1 (SD = 0.4) and at T3 was 2 (SD = 1), which also indicates that this was likely to be practical for the researcher and participants. The mean T4 session length was 29.42 minutes (SD = 4.54). The notes from the physiotherapists intervention implementation diary supported the practically of using the DASH and WOSI scores to prescribe an exercise regime as there was a range

of levels of exercises. Reflections within the diary identified that the same behaviour change technique could be used to achieve different effects: self-monitoring (behaviour change technique 2.4) was initially used as education then as persuasion.

Intervention fidelity

The intervention was implemented according to the protocol, apart from one final interview. One participant was unable to attend the final interview, this was conducted over the telephone with the participant sending the completed outcome measures by email.

All the participants' musculoskeletal prescriptions were based on the score from either DASH for the upper limb, or WOMAC for the lower limb. Intervention coherence was shown, as all domains and behaviour change techniques were used throughout the intervention and varied between participants at different time points dependent on the participants barriers to performing PA (Appendix 1). For example, many of the participants indicted that they did not have the discipline to regularly perform PA. So, at T1 behaviour change techniques of information on health consequences was frequently used, as well as education and persuasion, to increase the participant's PA. Additionally, persuasion about their own capacity to increase their PA and training on how to integrate activity into their everyday life was used. The phone calls at T2 and T3 focused on further enablement through problem-solving, further goal setting and action planning, persuasion through feedback on the outcome of the behaviour and verbal persuasion about capacity. At the final interview the focus was primarily on 'social and environmental opportunity' planning of other physical activities.

Participants were advised to complete the questionnaires 'to the best of their ability.' One participant answered the DASH score incompletely, and two participants needed clarification on the GLTEQ. This may have indicated incomplete understanding of the measures. Greater patient involvement and co-production in the next stage of the intervention development may help to establish whether comprehension of the measures is an issue that should be addressed.

Secondary clinical outcomes results

Missing data

IBM SPSS Missing Value Analysis (MVA) was used to ensure the data set was complete. Ethnicity and other surgery were missing from 1 participant (11.1%), details on past medical history was missing from 2 participants (22.2%). From the baseline assessment of the DASH score, data around questions on gardening, tennis, Frisbee, sex and social function was missing from 1 participant (11.1%). There was data missing on the final visit 6-minute walk test for 2 participants, as one participant was lost to follow up and another was unable to attend the final follow up but completed the other measures remotely.

Preliminary intervention effectiveness testing

Fifteen different physical activities were selected by the participants; mean number of goals per participant 3.85 (SD = 1.24). The activities the participants reported included: walking moderately vigorously (5/9), or power walking (3/9), aiming to walk > 10,000 steps daily (3/9), distances walked within specific time; dance (2/9), swimming (4/9), aqua aerobics (1/9), aerobic classes (2/9), cycling (1/9), netball (1/9), Zumba (1/9), (2) Hip Hop App, Pilates, Yoga or Tai Chi (3)

All participants received upper limb exercises. Seventy-seven percent of participants started with exercise sheet one, and all participants had progressed to sheet three by week six. For the lower limb two participants scored beneath the threshold for needing an exercise prescription. The remaining seven, were split between exercise sheet one and two. By week six, all had progressed to sheet two. All of the participants were given a musculoskeletal exercise prescription but only eighty-eight per cent reported they performed the exercises. At all-time points one participant consistently reported that she had not done the exercise prescription.

See Table 7 for full details of mean/median scores for the outcome measures, and results of the exploratory (underpowered) statistical analysis comparing changes over time. There was a significant improvement in distance walked within 6 minutes for the 6-minute walk test, from baseline median score 450 meters (IQR=175) to 550

meters (IQR=100) (Z= 22 8.00, p = 0.01, N=7). The GLTEQ also showed a positive change in overall PA levels from baseline median score 15 minutes per week (IQR =75) to 300.00 minutes per week (IQR= 330) (Z= 36.00, p = 0.01 N=8). There was a significant change in task self-efficacy from baseline score 37.50 (IQR =26.00) to 67.7 (IQR =28.38) (Z = 33.00 p = 0.04) and barrier self-efficacy, from baseline score 44.47 (SD = 21.61) to 73.05 (SD= 16.69) (t (7) = - 2.88 p = 0.02, N = 8) indicating increased confidence in ability to overcome the barriers and perform the task. The DASH scores showed no significant change. For WOMAC scores, the functional scores improved as it decreased significantly from baseline score, 13.00 (IQR= 40.00) to 9.50 (IQR = 32.00), (Z= 7.00, p = 0.01, N=8). The pain and stiffness WOMAC scores showed no significant changes.

Discussion

This study has shown that it is feasible to implement a tailored, individualised PA and musculoskeletal behaviour change intervention within the NHS. The recruitment rate of 25% (9/36), is within the range observed in other similar UK studies, of between 17% and 52 % (Daley et al., 2007; Fields et al., 2016; Gokal et al., 2015; Mutrie et al., 2007). The 77% retention rate is within range of other similar studies of between 64 to 84% (Daley et al., 2007; Fields et al., 2016; Gokal et al., 2015; Mutrie et al., 2007).

At T1 all participants received the initial outcome measures and information on the benefits of PA. They were all able to tailor their physical activity goal to overcome their individual barriers to PA. For example, social and contextual barriers were addressed with goals such as walking around the park with their grandchildren, or walking briskly as part of their commute. They were also able to develop and change their individual physical activity goals as evidenced by the wide range and variety of goals. For example, one participant agreed to go to a dance class with a friend but this was inconvenient so she ended up cycling with her husband. Physical and musculoskeletal barriers were addressed, for example, by using seated exercise phone Apps for participants who struggled to walk, or massage techniques to increase arm mobility for swimming. Other examples of activities included those based around walking, (such as power walking, step counts, walking measured distances) which addressed barriers around time, social commitments and discipline.

Other activities such as dance, aqua aerobics and cycling were selected as they as they were done with friends and family members which addressed barriers around enablement and social support. All participants reported tailoring and developing their physical activity goals and adding another goal at T2 and T3. This tailoring of the intervention is likely to have made it acceptable to participants, unlike previous UK studies where participants report being excluded due to contextual, environmental or physical MSK barriers. Mutrie et al. (2007), and Daly et al. (2007) report that 37% - 23%, respectively, of their potential participants were unable to attend the sessions due to contextual and environmental barriers; Fields et al (2016) reports that participants were unable to continue with the prescribed PA intervention due to MSK barriers. In contrast, the high levels of participant engagement and acceptability of the intervention from the current study is encouraging. However, the generalisability of these findings is unknown, as the number of participants was small.

At T1 all participants received their specific musculoskeletal exercise prescription. The MSK exercises were well received by all the participants and reportedly progressed by seven of them, which suggests they were actively engaged with the intervention. This is similar to other studies (Irwin et al., 2015, Harrington, 2011).

The feasibility of using the patient reported outcome measures as a source of information and tool to tailor the behaviour change techniques and the musculoskeletal prescription is demonstrated by the range of behaviour change techniques used, the musculoskeletal prescriptions used, and the variety of physical activity goals selected by the participants. This approach is therefore feasible, and promising as a standardised way to deliver an individually tailored PA intervention, and could be delivered by individuals without in depth behaviour change or physiotherapy training, and adapted to be used at scale.

The embedded intervention implementation diary was designed to assess the fidelity of the intervention delivery. However, this may have been biased, as the physiotherapist delivering the service also developed the intervention which may reduce the external validity of these observations (Craig et al 2008). The fact that the

participants reported engaging in physical activity suggests receipt of intervention however future tests of the intervention should include objective measures of intervention fidelity. The secondary outcome measures were not powered to assess intervention effectiveness in this feasibility study. However, the finding of a significant increase in physical activity levels and ability was encouraging, and suggests the intervention warrants further investigation. Furthermore, as participants completed most secondary measures easily, they can be seen as appropriate tools for the tailoring of the PA intervention and musculoskeletal exercise prescription.

A strength of this study is that it has shown that an individually tailored PA and physiotherapy behaviour change intervention for breast cancer survivors is acceptable to participants and feasible to deliver within the NHS. The intervention tailoring tools created (tables 2, 3 and 4) could feasibly be used by non-experts to promote selection of appropriate MSK exercises and effectively drive behaviour change. A second result is that the recruitment and retention rates were in line with other similar studies. A weakness in this study was that 1.8 participants were recruited monthly. This may have been due to restricting the time since diagnosis to 18 months. The doctor in the OAFU indicated that she would have referred more patients if this had been extended. This will be considered for future work.

In conclusion, this study has shown that it can be feasible to implement a PA and musculoskeletal exercise intervention for breast cancer survivors, using tools to individually tailor to both MSK difficulties and behavioural barriers. In line with the MRC complex intervention development framework, the intervention can now progress to the pilot stage of development before effectiveness testing (Craig et al ., 2008) The developed PA tool combined a validated measure of self-efficacy with the COM-B model and Behaviour Change Wheel, and allowed tailoring of the behaviour change intervention to individual barriers to PA. There was a positive change in PA levels which warrants future effectiveness testing. Following changes to the inclusion criteria, this intervention tool could feasibly be tested for effectiveness and cost-effectiveness.

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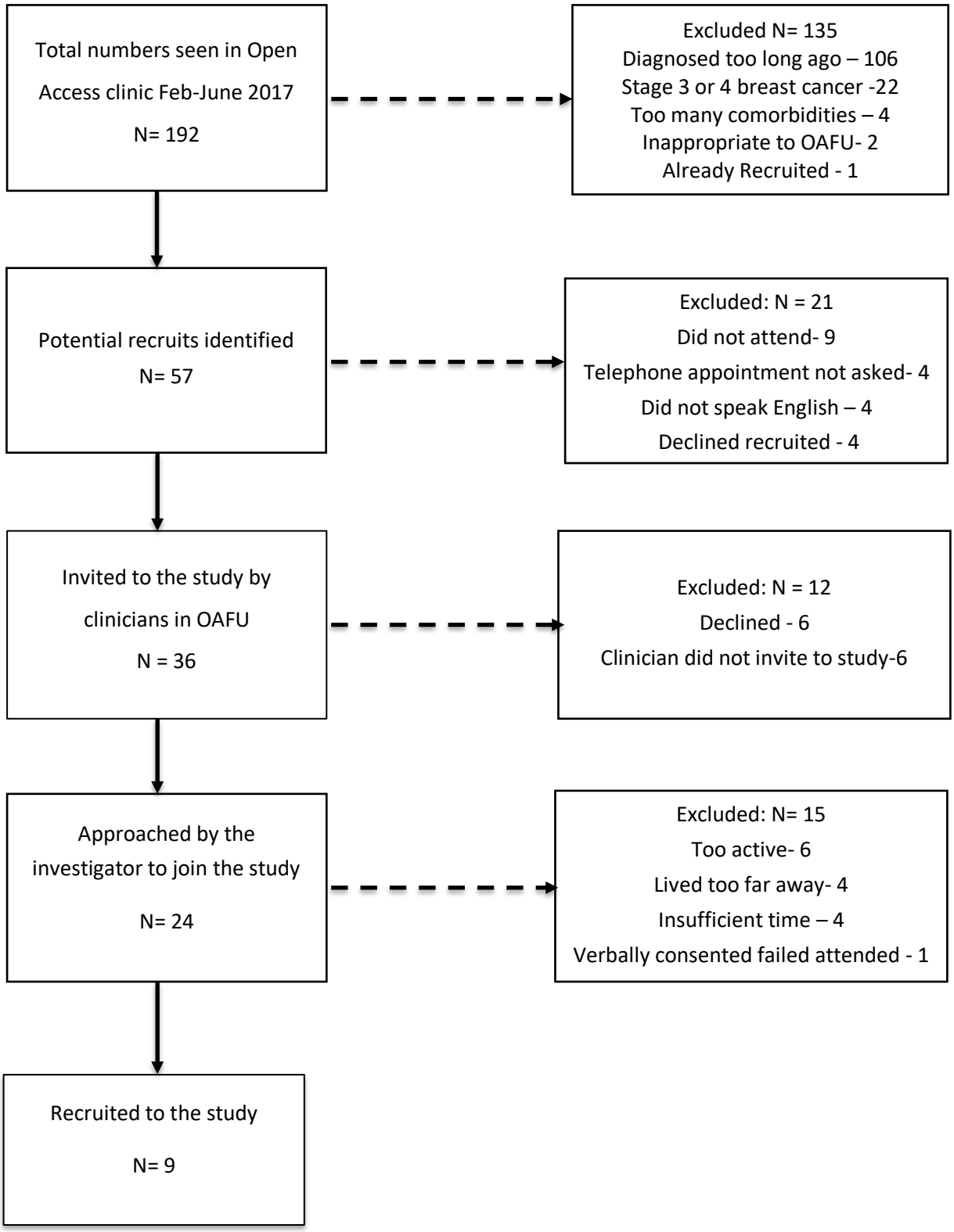
Figure 1 Recruitment flow chart



Tables

Week 1 (T1) Intervention Visit	**Baseline Assessment.** Completed patient reported outcome measures and measure of physical fitness. Exercise prescription was given, and physical activity goal developed based on questionnaire responses. Behaviour change intervention delivered using guide in Table 2.
Week 2 (T2) Telephone call	**Progress monitoring and support.** Progress with physical activity goal and exercise prescription discussed. Behaviour change techniques used to address barriers and facilitate progress.
Week 6 (T3) Telephone call	**Progress monitoring and support.** Further progress with physical activity and exercise prescription discussed. Behaviour change techniques used to address any barriers to the above and facilitate progress in physical activity goals and exercises.
Week 8 (T4) Post-Intervention visit	**Final assessment and satisfaction rating.** Repeat patient reported outcome measures and physical fitness assessment. Satisfaction questionnaire.

Table 1 Intervention procedure showing the details of the four different intervention time points.

Barrier Self-Efficacy Domain	**COM-B components served by intervention functions**	**Intervention Functions**	**Behaviour Change Techniques to Deliver Intervention Functions (N, from Behaviour Change Techniques Taxonomy (v1))**
Physical Health Tiredness,	Physical Capability	Training	Demonstration of the behaviour (6.1) Instruction on how to perform a behaviour (4.1) Feedback on the behaviour (2.2) Feedback on the outcomes of behaviour (2.4) Practice/ rehearsal of behaviour (8.1)
Physical Health	Physical Capability	Modelling	Demonstration of the behaviour physically (6.1) and through visualisation (4.1)
Discipline	Psychological Capability	Education	Information about health consequences (5.1) Prompts/cues (7.1) Feedback on behaviour (2.2) Self-monitoring of behaviour (2.4)
Priority Companion	Social Opportunity		Information about emotional consequences (5.6) (15.1) Verbal persuasion about capability. Focus on past success (15.3)
Weather	Physical Opportunity	Training	Feedback on the outcomes of behaviour (2.4) Practice/ rehearsal of behaviour (8.1) Habit formation habit reversal (8.2)
Interest, Enjoyment	Automatic Motivation	Persuasion	Credible source (9.1) Information about health consequences (5.1) Feedback on behaviour (2.2) Feedback on outcomes of behaviour (2.4)
Tiredness and Discipline	Reflective Motivation	Enablement	Goal setting behaviour goal setting (1.1) Problem solving (1.2) Goal setting outcomes (1.3) Outcome social contextual planning -(3.3) Social contextual Planning (12. 2) Action planning (1.4) Social support (3.2) Focus on past success (15.3)

Table 2 Mapping of the shared domains between the barrier self-efficacy questionnaire, COM-B model, intervention function and Behaviour Change Techniques including numbers from the Behaviour Change Techniques Taxonomy

(V1) Michie et al., 2013.

Exercise	**Set 1**	**Set 2**	**Set 3**	**Source of Evidence**
Flexion of shoulder	Passive supine lye	Step forwards and reach above head.	Standing lifting arm above head	Harris et al, 2004 Harrington et al, 2011.
Scapular stability work. Thoracic extension	Dust wall	Press up viz wall	Low row	Schmitz et al 2009, Lee et al, 2008.
Stretch of anterior chest	Doorway	Doorway	Higher range	Kilbraith et al, 2012.
Active assist Flexion, extension.	Pulley or standing active assist	Punching above head		Harris et al, 2004.
Resisted Flexion, extension			Resisted Flex / extension with weight	Harris et al, 2004, Harrington et al 2011.

Table 3 Upper Limb Exercises
The table shows the 3 sets of exercises that were used as the exercise prescription. Starting from the easier set 1 and working upwards.

Exercise	Set 1	Set 2	Source of Evidence
Resisted Flex	Seated no weight	Weight	Irwin et al. 2015, NICE guidelines 2014
Resisted Extension	Prone Flexion	Weighted	Irwin et al. 2015, NICE guidelines 2014
Hip extension	Sit- stand without arms-if too difficult extension in standing	Squat	Irwin et al. 2015, NICE guidelines 2014
Toe raises	With support of table	On stairs	Irwin et al. 2015,
Advice on good footwear			NICE 2014

Table 4 Lower Limb Exercises.

This shows the 2 sets of exercises used as the exercise prescription. Starting from the easier set 1 and working upwards

Variables	Participant Numbers (%) †
Characteristics.	**9 (100)**
Ethnicity (n= 8).	
White British	3 (33)
Black Mixed Irish	1 (11)
Black African	1 (11)
White Irish	1 (11)
Asian	1 (11)
Partner	
Yes	5 (55)
Employed	
Yes	6 (66)
Education	
GCSE/ O Levels	1 (11)
Diploma	5 (55)
University Degree	3 (33)
Breast Cancer Surgery	
No	1 (11)
Wide Local Excision	1 (11)
Lumpectomy	1 (11)
Mastectomy	4 (44)
Reconstruction	2 (22)
Radiotherapy	
Yes	5 (55)
Medication	
Analgesia	1
Letrozole † †	3
Aspirin,	1
Calcium Vit D,	1
Citalopram † † †,	1
Tramadol	1 (11)
Past Medical History	
Hypertension and Diabetes	1 (11)
Hypertension	1 (11)
Osteopenia	1 (11)
Sciatica	1 (11)

Table 5 Demographic and medical details. The data in this table was based on the demographic questionnaire participants completed at T1. †unless otherwise stated

total number is 9† †Letrozole is an aromatase inhibitor, † † †Citalopram is an antidepressant.

Affective Attitude: How an individual feels about the intervention
80-% participants, strongly recommend the intervention; 20% recommend the intervention
Comments: ‘Excellent I now realise how important exercise is and that I must make time for it and do more than prior to my diagnosis.’
Burden; - The perceived amount of effort that is required to participate in the intervention.
87 % (7/8) strongly disagreed, the first study meeting (T1) and phone calls were too long; 50 % strongly agreed the study was the correct length.
Comments: about phone interviews- ‘Feel they were necessary, changed some plans once had the discussion.’
Ethicality; - The extent to which the intervention has a good fit with the individuals’ value system
62 % (5/8) strongly agreed, 12 % (1/8) agreed the study took place at the correct time after the diagnosis.
Comments: ‘No issue with the time length or location.’
Intervention Coherence; - The extent to which the participants understand the intervention and how it works.
100-% of the participants reported they accepted the PA intervention – the behaviour change and exercise prescription. 100 % accepted the phone calls (T2, T3) and reported they had achieved their MVPA goals.
Comments: ‘Meeting with (first author name) was good for me as it encouraged me to take my health seriously by using the exercises, she gave me.’

Perceived Effectiveness; - The extent to which the intervention is perceived as likely to achieve its purpose
87 % (7/8) strongly agreed interview 1 increased PA; 87-% (7/8) agreed the discussion about PA was helpful. 87 % (7/8) agreed the phone calls increased PA. 87-% (7/8) agreed the exercise program helped to increase PA. 87% (7/8) overall agreed the intervention helped to increase PA levels.
Comments 'I am still continuing with the exercises as it helps relief my pains especially my right arm/shoulder, sitting and lifting from a chair.'
Self- Efficacy; The participants confidence that they can perform the behaviours' required to participate in the intervention
100-% agreed they would be able to incorporate PA into their life in general and would continue to be physically active
Comments: 'I had not realised that I would feel so much better if I was more active.'

Table 6 Acceptance framework and domains, based on Sekhon, Cartwright & Francis (2017).

The table shows how the domains, selected from the acceptance framework, were used to analyse the data from the satisfaction questionnaire, and from participant feedback during the study.

Outcome Measure	Baseline Mean Score (SD)	Baseline Median Score (IQR)	Follow-up Mean score (SD)	Follow up Median score (IQR)	Paired Sample t-test	Wilcoxon Signed Rank Test	N
Six-minute walk test		450 (175)		550 (100)		Z= 28.00, P= 0.001*	7
GLTEQ LSI		24 (25.50)		120.50 (137)		Z= 36, p= 0.001*	8

GLTEQ MVPA (reported)		15 (75)		300.00 (330)		Z= 36.00, p = 0.001*	8
Task Self-Efficacy		37.50 (26.00)		67.5 (28.38)		Z= 33.00, P = 0.04*	8
Barrier self-efficacy	44.47 (21.61)		73.05 (16.69)		t (7) = -2.88 p =0.02*		
DASH		20.83 (22.07)		10.40 (16.15)		Z= 7.0, p = 0.12	8
WOMAC		13.00 (57.92)		14 (38.75)		Z= 8.0, p = 0.16	8
WOMAC-Pain		3 (8.50)		2.00 (7.75)		Z= 6.5, p =0.40	8
WOMAC-Stiffness		1.00 (5.50)		1.00 (2.5)		Z = 2.0, p = 0.13	8
WOMAC-Functional Score		13.00 (40.00)		9.50 (32.00)		Z= 7.00, p = 0.001*	8

Table 7 shows the median and mean scores of the clinical outcome measures and the significance of any changes**.**

* Significant changes. N means total number of participants included in analysis.

Appendix 1

Taxonomy Code (V1) - Behaviour Change Technique	**T1**	**T2**	**T3**
5-1-Education- Information about Health consequences	9	6	6
7.1 -Education -Prompts/ clues	2	6	1
2.7- Education- Feedback on outcome of behaviour- feel better	0	2	3
2.4 -Education- Self monitoring	9	5	2
9.1-Persuasion- credible source health benefits MVPA	9	4	6
5.1-Persuasion -Information on health consequences overcoming Fatigue	8	5	4
2.4-Persusion-self monitoring feedback on outcomes of behaviour	0	6	9
15.1- Persuasion- Verbal persuasion about capability	9	9	9
15.3- Persuasion- Focus on past success	3	4	5
6.1-Training- Demonstration on how to perform specific exercises	8	5	6
4.1-Training instructions on how to perform MVPA in daily routine	7	4	3
2.2- Training- Feedback on behaviour	6	4	4
2.4- Training- Feedback on outcome of behaviour- self monitoring	9	7	7
8.1 Training- Practice or rehearsal of behaviour	9	9	6
8.1/ 8.2- Training- Habit formation/ habit reversal	9	6	9
1.1- Enablement- Behavioural goal setting	9	3	3
1.2- Enablement- Problem solving	9	9	5
1.3- Enablement- Goal setting outcome	9	9	6
3.3-Enablement- Social contextual planning- Local Facilities,	9	6	8

12.2-Enablement- Social contextual planning Other Activities	6	8	7
1.4 -Enablement- action planning	9	7	6
3.2-Enablement- Social support	2	5	4
15.3- Enablement- Focus on past success	4	5	6
6.1-Modelling- demonstration	8	0	0
4.1- Modelling- Visualisation	6	4	1

Table 8 of the BCT techniques used at each intervention point. Taxonomy codes from Behaviour Change Technique Taxonomy V1 (Michie et al., 2013).